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## **Gulf of Maine haddock**

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## **1.0 Abstract**

The 2008 GARM Models Meeting Review Panel reviewed the use of An Index Method (AIM) for the Gulf of Maine haddock. The Panel supported the use of the AIM model to estimate biological reference points (BRP) though they encouraged the exploration of an age-structured assessment. Age-structured assessments were not performed in previous assessments because of the limited availability of biological samples in the late 1980's through the mid 1990's. In the current assessment a Virtual Population Analysis (VPA) of the Gulf of Maine haddock stock was performed. Model diagnostics are comparable to those from recent accepted assessments of Georges Bank haddock suggesting that the VPA is a good candidate model. Based on the VPA assessment and both parametric and non-parametric estimations of BRPs, the current stock status is not overfished and overfishing is not occurring. The non-parametric method is preferred since the parametric estimations of BRPs suffer from a poor fit of the stock-recruit function. The VPA estimated 2006 fishing mortality ( $F$ ) at 0.219 ( $F_{40\%} = 0.367$ ). There is an 80% probability that the 2006  $F$  was between 0.168 and 0.344. The 2006 spawning stock biomass (SSB) was estimated at 6,345 mt (non-parametric  $SSB_{MSY} = 3,700$  mt), with an 80% probability of being between 5,102 mt and 8,193 mt. The moderately sized 2003 year class (5.2 million fish) will constitute the largest fraction of the fishery over the next several years since no strong year classes have been observed since 1998.

## **2.0 Background**

Gulf of Maine haddock biological reference points were last updated in 2002 using An Index Method (AIM<sup>1</sup>, NEFSC 2002a). The proxy  $F_{MSY}$  (exploitation rate index) and  $B_{Threshold}$  ( $1/2 B_{MSY}$ ) were estimated at 0.23 and 11.09 kg/tow, respectively (NEFSC 2002a). This stock was last assessed and peer reviewed at the GARM in August 2005 (NEFSC 2005). At this assessment the terminal year (2004) exploitation rate index was 0.18 and the 3-year survey biomass index was 5.79 kg/tow. Stock status was overfished but overfishing was not occurring.

The 2005 assessment did not include estimates of recreational catch or commercial discards in the exploitation rate. The 2005 GARM Review Panel recommended that future assessments include recreational catches in estimates of fishery removals and that an age-structured model be attempted. Past assessments have not used age-structured models because biological data (length frequencies, age and maturity sampling) were sparse during the late 80s and early- to mid-90s (NEFSC 2001). The 2008 GARM Models Meeting Review Panel (O'Boyle, 2008) also encouraged the exploration of age-structured models but supported the AIM model as a fall-back method for the determination of biological reference points.

## **3.0 The Fishery**

### *Commercial landings*

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<sup>1</sup> NOAA Fisheries <http://nft.nefsc.noaa.gov/Toolbox> Version 3.0, 2008. An Index Method (AIM) Version 2.0. [Internet address: <http://nft.nefsc.noaa.gov>].

For the purposes of describing fishery removals, the Gulf of Maine region is defined as statistical areas 510 – 515 (NAFO area 5Y, Fig. R1). United States (US) landings were extracted from Northeast Fisheries Science Center's (NEFSC) commercial fisheries database (CFDBS) AA tables. US landings with unknown statistical areas were apportioned among northeast haddock stock complexes based on a standard algorithm (Palmer, 2008). Landings with unknown statistical areas constituted a minor fraction of the overall landings. International landings post-1960 were updated from NAFO Fisheries Statistics reports (<http://www.nafo.int>); pre-1960 landings extracted from Clark et al. (1982).

The fishery has been largely dominated by the US domestic fleet (Table R1; Fig.R2). There were two periods of significant Canadian landings, the first from 1965 to 1968 and the second from 1978 to 1986. Domestic landings remained above 4,500 mt until 1967, subsequently dropping below 600 mt in 1973 before rising back above 6000 mt by 1980. Landings remained above 3000 mt then decreased to 120 mt by 1994. Landings gradually increased after 1994 and remained relatively constant at approximately 1000 mt from 2003 to 2005. Landings dropped off in 2006 to just under 620 mt.

#### *Commercial discards*

Discards were estimated for five commercial fleets: the large mesh bottom otter trawl ( $\geq 5.5''$ ), small mesh bottom otter trawl ( $< 5.5''$ ), benthic longline, sink gillnet, midwater-paired otter trawl, and midwater otter trawl fleets. These five fleets constitute the majority of total Gulf of Maine haddock discards (Table R2). For years where direct observations of commercial discards were made by at-sea observers (1989 – present) estimates of commercial discards were calculated using the combined-ratio method (Wigley et al. 2007). Discards prior to 1989 were estimated using the survey-scaling method (Palmer et al. 2008). With the exception of the period from 1994 to 1997 when possession limits ranged from 500 to 1,000 lb/day, Gulf of Maine haddock are primarily discarded because of minimum size limits (Table R3). Federal size limits were first imposed in 1977 and have ranged from 16" to 19" for the commercial fishery (Table R4). It was assumed that the primary reason for discards in the period before 1994 are similar to the most recent period, i.e., below minimum size. It is unknown whether groundfish quotas in place in the late 1970's to early 1980's resulted in significant discarding of legal sized fish.

The combined ratio,  $r_c$  from the recent period are comparable to those prior to 1994 for most fleets (Table R5; limited or no coverage was available for three of the six estimated fleets prior to 1994). It was assumed that an average of the 2003 to 2006 fleet discard ratios could be applied back in time to estimate historical discards by accounting for changes in the biomass of the undersized and exploitable fraction of the population as observed in the NEFSC autumn bottom trawl survey biomass indices. The undersized and exploitable fraction of the population is assumed to represent that portion of the population that is vulnerable to capture by fleet,  $h$ , but below the minimum size limits (or 5<sup>th</sup> percentile of length frequencies observed in commercial landings for those years where no minimum size restrictions existed). A three-year centered moving average was applied to the survey indices to remove noise.

Commercial discards average less than 100 mt per year. There are two predominant peaks in discards, the first between 1964 to 1966 when there was an abundance of undersized fish and a second from 1994 to 1997 when restrictive trip limits were in place (Table R5). Discards constitute a minor fraction of total fishery removals with the exception of the 1994 to 1997 period (Fig. R2).

#### *Recreational catch*

Recreational landings (types A and B1 catch) of Gulf of Maine haddock were obtained from the Marine Recreational Fisheries Statistics Survey (MRFSS). Landings were partitioned among stock complexes using a standard algorithm (S. Steinback pers. comm.). Data are available from 1981 onward. Historically, recreational landings have been a minor component of overall fishery removals, though in recent years recreational landings have averaged just over 500 mt (Table R6; Fig. R2).

#### **4.0 Length-Weight Relationships**

Length-weight relationships were calculated using NEFSC bottom trawl survey data from 1992 to 2007. Prior to 1992 individual weights were not recorded in the bottom trawl survey. Spring survey data were used to represent the relationship during the first two quarters of the calendar year and the autumn survey for quarters three and four. Regression equations were calculated using non-linear least squares regression. The representative equations for each half year block are:

$$\text{Spring: } W_{\text{live (kg)}} = 0.00000769 \cdot L_{(\text{fork cm})}^{3.0622} \quad (p < 0.0001, n=2502)$$

$$\text{Autumn: } W_{\text{live (kg)}} = 0.00000987 \cdot L_{(\text{fork cm})}^{3.0987} \quad (p < 0.0001, n=4890)$$

#### **5.0 Biological Sampling and Estimates of Catch at Age**

Length and age samples of US commercial landings were collected through the Northeast Region port sampling program. These samples are used to partition landings into numerical catch at age. Sampling of landings are stratified by market category (scrod and large) and quarter. To the extent possible catches-at-age were estimated using the same stratification used to collect the port samples (i.e., by quarter and market category), however in some years where available length/age data were insufficient to characterize the catch, quarters were grouped to achieve full length frequency distributions. Port sampling intensity was low prior to 1977 (Table R7 and R8). From 1977 on, sampling remained relatively high until the late-1980s when landings declined. Sampling remained low until 1997 when trip limit restrictions were relaxed and landings increased. Age-length keys were supplemented with survey age data to the extent possible when the number of ages per year was less than 100. Commercial landings at age were estimated from 1977 to the present using the NEFSC Commercial Data Biostatistical Analysis Program (BioStat v 5.10<sup>2</sup>) software (Table R9). Uncertainty in the catch at age was

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<sup>2</sup> NOAA Fisheries Toolbox Version 2.10, 2006. Commercial Data Biostatistical Analysis Program 5.10. [Internet address: <http://nft.nefsc.noaa.gov> ].

determined using the BioStat bootstrap option (1000 realizations; Legault et al. 2007). The catch at age coefficients of variation (CV) ranged from 6 - 107% for the fully recruited portion of the population (ages 4 -8), but were generally less than 30% (Table R10). CVs are large for the youngest and oldest age classes. Catch at age uncertainty could only be determined back to 1984; before 1984 individual samples can not at present be identified in the database. Based on the higher CV at older ages and truncation of the older ages classes at low stock abundance a plus group of 9<sup>+</sup> was used for all age-specific indices.

Length and age samples of commercial discards are collected by the Northeast Fisheries Observer Program. The number of individual lengths sampled annually has varied from zero in 1990 to over 700 in 2005 (Table R11). Because of the relative sparseness of discard sampling, a non-fleet specific annual discard length frequency was used to characterize the length distribution of the catch. In years where the total number of sampled fish was less than 100, discard length frequencies were supplemented by the length frequency distribution of fish from the NEFSC surveys that were below the minimum size (or 5<sup>th</sup> percentile observed in commercial landings for those years where no minimum size restrictions existed). Age-length keys were supplemented with survey age data in all years. Discards at age were estimated from 1977 to the present using the BioStat software (Table R12). Because of the combined nature of the discard biosampling sources (i.e., discards and survey) analyses of the uncertainty in the discards at age could not be assessed.

Recreational length samples were extremely limited prior to 2002 (Table R6). The size distribution of haddock landed by the recreational fishery is similar to those of the commercial longline fishery and from those fish captured in the bottom trawl survey above the recreational minimum size (Table R4; Fig. R3). Length samples before 2002 were supplemented with length frequency data from these sources. Because no ages were sampled from the recreational fishery age-length keys were obtained from survey age data for all years. Recreational landings at age were estimated from 1981 to the present using the BioStat software (Table R13). Because of the combined nature of the recreational landings biosampling sources (i.e., MRFSS survey, commercial longline and survey) analyses of the uncertainty in the discards at age could not be assessed.

## 6.0 Research Survey Indices

NEFSC bottom trawl survey indices of abundance (stratified mean number per tow) and biomass (stratified mean kg per tow) were estimated from both the NEFSC spring and autumn bottom trawl surveys from 1963 to 2007 (spring survey started in 1968). The indices include catch data from stations within the NEFSC offshore survey strata 01260 – 01280 and 01360 – 01400 (Fig. R4). The survey indices were adjusted for differences between the fishing power of the Albatross IV and Delaware II and for differences in the catchability of the BMV trawl doors used prior to 1985 (Forrester et al., 1997; Table R14). Spring and autumn survey indices exhibit similar trends over the time series (Table R15; Fig. R5). However, mature age classes tend to be more available to the autumn

survey (Fig. R6) presumably because of the inshore spawning migrations of Gulf of Maine haddock during the spring.

Indices declined from highs in the mid-1960's to lows in the early 1970's before again increasing during the late 1970's and early 1980's. The period from 1987 to 1992 experienced record-low indices. Increases have been observed since 1997 with current indices equal to those observed during the late 1970's and early 1980's. The increases in both abundance and biomass observed throughout the time series have been largely driven by moderate to strong year classes observed in 1963, 1975, 1998, and 2003 (Fig. R7 and R8) that track strongly through the survey abundance at age matrices (Table R16 and R17). Survey biological sampling (lengths, ages) was sparse during the late 1980s and early to mid-1990s during the periods of low stock abundance (Table R18).

Questions were raised by the GARM Model Review Panel as to whether some of the productivity attributed to the Gulf of Maine haddock stock complex is actually spillover from the Great South Channel area of the Georges Bank stock (O'Boyle, 2008). There is a strong correlation between the Gulf of Maine and Georges Bank survey biomass indices ( $r = 0.5453$ ,  $p = 0.0002$ ,  $n = 45$ ), however the spatial distribution of the stocks at low survey biomass levels suggests that there are discreet aggregations of haddock in the Gulf of Maine. These aggregations are most evident in the vicinity of Stellwagen Bank, Jeffreys Ledge and the southern edge of the Jordan Basin (Fig. R9). The historical presence of spawning aggregations within the Gulf of Maine (Begg, 1998) and differences in recruitment patterns (i.e., the 1998 year class was of a far less relative magnitude on Georges Bank) suggest that it is appropriate to consider these stock complexes separately.

## **7.0 Mean Weight at Age**

Mean weights at age for the domestic US fishery were calculated using the BioStat software application for both the commercial landings and discards. Total catch (landings and discards) average weights at age were calculated using abundance weighted averages. Recreational catch was not included in these averages because of a lack of biological samples from this fishery component; it is expected that the weight-at-age of recreational landings are consistent with the commercial landings. In general, mean weights of the commercial catch have declined in recent years (Table R19). A similar trend has been observed in survey weights at age (Table R20) and lengths at age over time (Fig. R10 and R11).

## **8.0 Natural Mortality**

Natural mortality estimates have not been considered in previous assessments of Gulf of Maine haddock. The longevity of Gulf of Maine haddock is similar to that of Georges Bank haddock (e.g., 15 years), thus an assumption of 0.2 was used consistent with previous Georges Bank assessments (NEFSC, 2005).

## **9.0 Maturity Ogives**

A logistic regression method (O'Brien et al. 1993) was used to fit maturity at age from the NEFSC spring survey data. Attempts were made to estimate maturity-at-age using 3, 5, 7 and 9-yr centered moving averages to smooth the noise in the data and increase sample sizes for those years with low sampling (Table R21). However, because of a lack of maturity observations during the late 1980's to mid-1990's and the consistent presence of a knife-edge maturity pattern (i.e. fish transitions from nearly 100% immature to 100% mature between the ages of 2 and 4) a single time series average of maturity at age was used to achieve sufficient sample sizes (Table R22). A single time series maturity ogive is not unreasonable given the lack of observable trends in the age at 50% maturity ( $A_{50\%}$ ; Fig. R12). The estimated  $A_{50\%}$  for Gulf of Maine haddock was 2.43 years for females and 2.04 years for males.

## **10.0 Assessment Results**

### *An Index Method (AIM)*

The 2005 assessment of Gulf of Maine haddock used reference points last updated in 2002 (NEFSC 2002) which were calculated using an AIM model. The proxy exploitation rates index ( $F_{MSY}$ ) and  $B_{Threshold}$  ( $1/2 B_{MSY}$ ) were estimated at 0.23 and 11.09 kg/tow respectively. For this current reference point meeting, the reference points were first updated using the revised AA landings data and updated survey indices using the same times series (1963 to 2000) used in 2002. The updated data resulted in a slight increase in  $F_{MSY}$  0.26 and a decrease in  $B_{Threshold}$  to 9.71 kg/tow (Table R23). The reference points were then re-calculated using the full time series now available (1963 to 2006) and incorporating recreational landings and commercial discards. The resulting reference points were similar to previous reference points (0.23 and 10.98 kg/tow respectively), however the most current F-proxy estimate increased to 0.29 with the addition of recreational landings and commercial discards. The current 3-year average survey biomass index is 4.09 kg/tow. Based on the AIM model the current stock status is over fished and over fishing is occurring.

### *Long-term Observation-error Survey Series (LOSS)*

The GARM 2008 Models Meeting Panel recommended that for stocks currently using the Relative Trend class of models (e.g., AIM) "alternative models should be explored that both have a stronger basis in biology and more explicitly address uncertainty" (O'Boyle, 2008). An age-structured production model, the Long-term Observation-error Survey Series (LOSS) model was attempted for Gulf of Maine haddock using the same time series of survey indices and total fishery removals used in the AIM model (a detailed description is provided in Palmer and Legault, 2008). Given the inability to determine a "best" model formulation and the wide ranging implications on stock status, the LOSS model is not a good candidate with which to determine biological reference points for Gulf of Maine haddock.

### *Virtual Population Analysis (VPA)*

Per recommendations of previous GARM Review Panels, a Virtual Population Assessment (VPA) model was performed on Gulf of Maine haddock. The VPA input data

included catch, survey and biological data for years 1977 through 2006 with a maximum age of 9<sup>+</sup>. These decisions were based on the availability of biological sampling and high CVs in the catch at age estimates for the older age classes. Several VPA calibration runs were undertaken to assess the sensitivity of the VPA results to inclusion/exclusion of the survey indices at age (Table R24). The selected calibration run (run 12, hereafter referred to as the “base” run) included catch at age estimates of ages 1 to 9<sup>+</sup> and survey abundance at age (age 1 and above), however, the spring survey and autumn surveys plus groups began at age-6 and age-8 respectively because of the low survey detectability of the older age classes (Table R16 and R17). Age 0 survey indices were not included from either spring or autumn survey because of the low detectability of this age class.

Overall, the coefficients of variation (CV) on the terminal year, t+1, estimates of population numbers are comparable with past Georges Bank haddock assessments (NEFSC 1998, NEFSC 2005). The CV on age 1 is relatively high (0.69), but decreases to < 0.60 for older age classes. Survey selectivity at age ( $q$ ) ranged from 0.17 to 0.21 for the spring survey and 0.13 to 0.28 for the autumn survey. Standardized residuals for both surveys are plotted in Figure R12 (spring) and R13 (autumn). There are no strong residual patterns present among any of the survey indices. No retrospective patterns are observable in either the estimated Fs (Fig. R15) or recruitment (Fig. R16). There are minor retrospective patterns in the spawning stock biomass (Fig. R17) and total stock number estimates (Fig. R18). However, bootstrap results suggest these are not strong patterns as evidenced by the lack of overlap in the distributions about the point estimates in the retrospective plots (Fig. R19 and R20).

The VPA assessment results indicate the stock numbers were around 28 million fish during the late 1970s and declined to 1.7 million fish by 1990 (Table R25). The high abundances in the late 1970s was driven by the strong year class of 1975 and moderate year classes of 1978 and 1979 (Fig. R21). No strong year classes were observed until 1998, though two back-to-back moderate strength year classes in 1993 and 1994 began a steady increase in population numbers following the low of 1990. A very strong year class developed in 1998 of a similar magnitude similar to that of 1975. The 1998 year class increased stock numbers above 20 million for the first time since 1980. Several moderate year classes have been observed since 1998 that have sustained a current population size of approximately 10 million. There is some evidence of a moderately strong year class in 2003, but not of the magnitude observed on Georges Bank (NEFSC, 2005).

Spawning stock biomass (SSB) was estimated at approximately 15,000 mt during the early 1980s, declining to a low of 600 mt by 1989 (Table R26). The improved recruitment during the mid-1990s combined with the strong 1998 year class led to a recent peak in the SSB in 2002 at around 12,000 mt (Fig. R22). SSB has since declined as the 1998 year class is removed from the population. The 2003 year class should be fully mature by 2007. The increases in SSB observed throughout the time series have occurred as a result of strong recruitment and expansions of the age structure to include more mature fish in the population. The expansion of the age structure following the high recruitment in the late 1970’s is evident in both the January 1 biomass at age estimates

(Table R27) and the mean biomass at age estimates (Table R28). Low recruitment and high fishing mortality ( $F_{4-8} > 0.5$ ; Table R29; Fig. R23) during the period from 1983 to 1991 reduced the biomass of the older age classes. With fishing mortalities in the recent period below  $F_{4-8}$  of 0.3 combined with strong to moderate recruitment, the current population age structure has expanded to levels similar to those observed in the early 1980's. The 2006 SSB is estimated at 6,345 mt and the fully-recruited fishing mortality,  $F_{4-8}$ , at 0.219

The uncertainty of the VPA SSB and F point estimates were assessed by means of bootstrap analysis of the VPA. One thousand bootstrap realizations were produced through random resampling of the survey residuals from the base run. The 2006 SSB point estimate of 6,345 mt has an 80% confidence interval of 5,102 mt to 8,193 mt. The 80% confidence interval of the 2006 F point estimate of 0.219 ranged from 0.168 to 0.344 (Fig. R24).

## 11.0 Biological Reference Points

The Working Group on Re-Evaluation of Biological Reference Points for New England Groundfish (NEFSC 2002) estimated biological reference points (BRPs) for the Gulf of Maine haddock using the AIM method. With age-based assessment results now available for the current assessment, BRPs should be estimated using yield per recruit/SSB per recruit analyses (non-parametric) and/or Beverton-Holt stock recruitment models (parametric) based on the VPA results.

### *Empirical non-parametric determination (Yield per Recruit)*

Input vectors for the yield per recruit (YPR) and SSB per recruit (SSBR) analyses (selectivity, natural mortality, stock weights, catch weights and spawning stock weights) were estimated as un-weighted averages of the most recent five years (2002 to 2006; Table R30). Using an average of the recent values for the purposes of yield projections is cause for concern given the observed decline in haddock size at age (Tables R19 and R20; Figs. R10 and R11). However, without a better understanding of the underlying cause(s), the current biological parameters are the best indicator of future parameters. No trends were observed in the maturity (Fig. R12) and the current population age-structure is similar to that observed in the 1970's (Fig. 8). Fishing mortality estimates from the yield per recruit analysis were  $F_{0.1} = 0.324$ ,  $F_{40\%} = 0.368$  and  $F_{\max} = 1.373$  (all fully recruited Fs). The spawning stock biomass per recruit and yield per recruit at  $F_{40\%}$  were estimated at 2.037 and 0.516 kg/recruit respectively (Table R31, Fig. R25).

### *Parametric determination (Stock-recruit function)*

Maximum likelihood fit of the Beverton-Holt stock recruit function was determined using VPA estimates of age-1 recruitment and spawning stock biomass. No priors were specified. The stock recruit model estimated  $F_{\text{MSY}}$  at 0.445 (Table R32). The stock recruit function (Fig. R26) predicts expected recruitment values of approximately 2.0 million fish at the current levels of spawning stock biomass; a level in excess of the average recruitment. There is a strong residual pattern present in the fit (Fig. R27).

#### *Biological reference point determination*

Gulf of Maine haddock biological reference points were estimated using both the non-parametric and parametric approaches based on the results of the VPA base run.  $SSB_{MSY}$  and MSY values were estimated from the median values of spawning stock biomass and yield derived from long-term projections (50 years) of the Age Structured Model Projections (AGEPRO<sup>3</sup>) model (Brodziak and Rago, 1994; Brodziak et al., 1998). Input vectors for the AGEPRO runs are the same as those used for the YPR/SSBR analyses (Table R30). The non-parametric BRP estimation used a stochastic projection using the cumulative density function of the VPA age-1 recruitment series from 1977 to 2006 (median age-1 recruitment = 1.5 million fish) and an assumed harvest of  $F_{40\%} = 0.368$ .  $SSB_{MSY}$  was estimated at 3,700 mt and MSY was estimated at 900 mt (Table R33). The parametric BRP estimation used the Beverton-Holt stock recruit function ( $\alpha=3.04671$ ,  $\beta=1.41491$ , steepness = 0.73982) and an assumed harvest of  $F_{MSY} = 0.445$ .  $SSB_{MSY}$  was estimated at 6,700 mt and MSY was estimated at 1,400 mt.

### **12.0 Projections**

Because of the poor fits of the Beverton-Holt stock recruit model, projections of future stock status should be conducted using the non-parametric BRP estimation methods. Averages of mean weights at age, maturities at age and partial recruitment patterns from the most recent five years best reflect the conditions of future populations and fisheries.

### **13.0 Stock Status Summary**

Based on BRPs calculated with both the non-parametric and parametric approaches the Gulf of Maine haddock stock status is not overfished and overfishing is not occurring. The VPA estimated 2006 fishing mortality (F) at 0.219. There is an 80% probability that the 2006 F was between 0.168 and 0.344. The 2006 spawning stock biomass (SSB) was estimated at 6,345 mt, with an 80% probability of being between 5,102 mt and 8,193 mt. No strong year classes have been observed since 1998. The moderately sized 2003 year class (5.2 million fish) will constitute the largest fraction of the fishery over the next several years since no strong year classes have been observed since 1998.

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<sup>3</sup> NOAA Fisheries <http://nft.nefsc.noaa.gov/Toolbox> Version 3.0, 2008. Age Structured Model Projections (AGEPRO). Version 3.1.3. [Internet address: <http://nft.nefsc.noaa.gov>].

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## 15.0 Tables

Table R1. Gulf of Maine haddock commercial landings by country, 1956 – 2006. The Gulf of Maine stock comprises Northwest Atlantic Fisheries Organization division 5Y and United States (US) statistical areas 511 – 515.

Year	US <sub>revised</sub>	Canada	USSR	Other	Total
1956	7278	29	0	0	7307
1957	6141	25	0	0	6166
1958	7082	285	0	0	7367
1959	4497	163	0	0	4660
1960	4541	383	0	0	4924
1961	5297	56	0	0	5353
1962	5003	107	0	0	5110
1963	4742	3	44	0	4789
1964	5379	70	0	0	5449
1965	4155	159	0	0	4314
1966	4524	1125	0	0	5649
1967	4852	589	0	0	5440
1968	3417	120	0	0	3537
1969	2405	59	0	231	2695
1970	1436	38	0	67	1541
1971	1190	85	0	27	1302
1972	912	23	4	0	939
1973	526	49	0	0	575
1974	629	198	0	9	836
1975	1180	79	0	4	1263
1976	1835	91	0	0	1926
1977	3230	26	0	0	3256
1978	4382	641	0	0	5023
1979	4131	257	0	0	4388
1980	6318	203	0	0	6521
1981	5720	513	0	0	6226
1982	5637	1278	0	0	6912
1983	5593	2003	0	0	7596
1984	2793	1245	0	0	4038
1985	2234	791	0	0	3025
1986	1590	225	0	0	1815
1987	829	0	0	0	829
1988	416	0	0	0	416
1989	264	0	0	0	264
1990	433	0	0	0	433
1991	431	0	0	0	431
1992	312	0	0	0	312
1993	193	0	0	0	193
1994	120	0	0	0	120
1995	173	0	0	0	173
1996	247	0	0	0	246
1997	589	0	0	0	589
1998	885	0	0	0	884
1999	543	0	0	0	541
2000	738	0	0	0	738
2001	929	0	0	0	929
2002	977	0	0	0	977
2003	1023	0	0	0	1023
2004	946	0	0	0	946
2005	962	0	0	0	962
2006	618	0	0	0	618
Average	1993	229	0	8	2230

Table R2. Discards of Gulf of Maine haddock by fleet as observed by the Northeast Fisheries Observer Program (NEFOP), 1989 to 2006.

Year	Otter trawl, bottom, large mesh ( $\geq 5.5"$ )	Otter trawl, bottom, small mesh (< 5.5")	Otter trawl, paired- midwater	Otter trawl, midwater	Longline, benthic	Gillnet, sink	Other	Percent of total discards by other fleets (%)
1989	28	1				37	2	0.03
1990	2	0				28	9	0.23
1991	26	0			6	193	4	0.02
1992	146	0			0	121	22	0.08
1993	155	0			0	161	47	0.13
1994	149					67	47	0.18
1995	1705	29		0		60	37	0.02
1996	704	97				204	15	0.01
1997	2679	0				2	4	0.00
1998	28					56	0	0.00
1999	3	8	0			70	0	0.00
2000	355			0		140	0	0.00
2001	244	249				56	0	0.00
2002	261	92			0	185	0	0.00
2003	974	33	0	0	152	348	0	0.00
2004	758	367	340	263	12	591	2	0.00
2005	1762	127	1098	243	1196	828	1	0.00
2006	1916	53	0	6	761	156	21	0.01
Total	11894	1055	1438	512	2127	3300	210	0.01
Annual average	661	70	288	85	266	183	12	0.01

Table R3. Discard reasons by year described as a percent occurrence from Northeast Fisheries Observer Program (NEFOP), 1989 to 2006.

Year	Discard reason by percent of total weight				Total weight of discards with discard reason available (lb)	Count of observed hauls with discard reasons available
	Other / unknown	Quota filled / retention prohibited	Upgraded	Poor quality		
1989	49.3	0.0	0.0	50.7	0.0	69
1990	66.7	0.0	0.0	33.3	0.0	30
1991	71.1	0.0	0.0	28.9	0.0	225
1992	79.8	0.0	0.0	20.2	0.0	297
1993	72.2	13.6	0.0	14.2	0.0	316
1994	47.8	42.7	0.0	0.0	9.5	216
1995	22.5	46.9	0.0	0.5	30.1	1,794
1996	1.0	29.6	13.1	5.6	50.7	1,095
1997	4.8	34.5	0.0	50.5	10.2	4,173
1998	44.2	0.0	0.0	4.4	51.4	91
1999	9.9	0.0	0.0	76.5	13.6	81
2000	0.2	0.0	0.0	22.6	77.3	532
2001	2.6	0.0	0.0	3.9	93.5	696
2002	4.9	0.0	0.0	16.0	79.1	614
2003	1.9	0.0	0.0	7.7	90.3	1,544
2004	48.6	0.0	0.0	9.0	42.5	2,876
2005	24.8	0.6	0.0	13.3	61.3	5,178
2006	0.9	0.0	0.0	2.7	96.4	2,854
2007	12.2	0.0	0.0	34.5	53.2	3,006

Table R4. Gulf of Maine haddock minimum size limits for commercial and recreational landings, 1977 to 2006. Prior to 1977 there were no federal minimum size limits for either fishery. Values in italics are assumed pending clarification of regulations.

Year	Commercial minimum size limit (total length, inches)	Recreational minimum size limit (total length, inches)	Management action
1977	16	<i>15</i>	Groundfish Fishery Management Plan
1978	16	<i>15</i>	
1979	16	<i>15</i>	
1980	16	<i>15</i>	
1981	16	<i>15</i>	
1982	16	<i>15</i>	
1983	17	<i>15</i>	Large-mesh multispecies Fishery Management Plan
1984	17	<i>15</i>	
1985	17	<i>15</i>	
1986	17	<i>15</i>	
1987	19	<i>17</i>	Amendment 1
1988	19	<i>17</i>	
1989	19	<i>19</i>	
1990	19	<i>19</i>	
1991	19	<i>19</i>	
1992	19	<i>19</i>	
1993	19	<i>19</i>	
1994	19	<i>19</i>	Amendment 5
1995	19	<i>19</i>	
1996	19	<i>19</i>	
1997	19	<i>19</i>	
1998	19	<i>19</i>	
1999	19	<i>19</i>	
2000	19	<i>19</i>	
2001	19	<i>19</i>	
2002	19	<i>23</i>	Framework 33
2003	19	<i>21</i>	Framework 22
2004	19	<i>19</i>	Amendment 13
2005	19	<i>19</i>	
2006	19	<i>19</i>	
2007	18	<i>19</i>	Emergency action (August 10, 2007 through February 6, 2008)
2008	18	<i>19</i>	

Table R5. Gulf of Maine haddock discards (mt) and coefficients of variation (CV) for the benthic longline, large mesh otter trawl, small mesh otter trawl, paired-midwater otter trawl and midwater otter trawl fleets, 1964 – 2006. Discards from 1989 – 2006 were derived using a combined-ratio estimator of Gulf of Maine haddock discards to the retained amount of all species. Discards from 1964 – 1988 were derived using survey scaling method; no estimates of variability are available for these numbers.

Year	Longline, benthic		Otter trawl, bottom, large mesh ( $\geq 5.5"$ )		Otter trawl, bottom, small mesh ( $< 5.5"$ )		Gillnet, sink		Otter trawl, paired-midwater		Otter trawl, midwater		Total	
	discards (mt)	CV	discards (mt)	CV	discards (mt)	CV	discards (mt)	CV	discards (mt)	CV	discards (mt)	CV	discards (mt)	CV
1964	132.5		0.0		255.0		4.7		0.0		0.0		392.2	
1965	168.7		0.0		138.3		3.3		0.0		0.0		310.3	
1966	90.9		0.0		111.1		4.1		0.0		0.0		206.1	
1967	17.7		0.0		39.8		1.5		0.0		0.0		59.0	
1968	4.4		0.0		14.8		0.6		0.0		0.0		19.8	
1969	0.5		0.0		2.3		0.1		0.0		0.0		2.8	
1970	0.5		0.0		1.8		0.0		0.0		0.0		2.3	
1971	3.4		0.0		10.3		0.3		0.0		0.0		14.0	
1972	5.8		0.0		9.4		0.4		0.0		0.0		15.6	
1973	13.6		0.0		17.2		1.0		0.0		0.0		31.8	
1974	18.0		0.0		18.2		2.0		0.0		0.0		38.3	
1975	38.9		0.0		26.9		3.7		0.1		0.0		69.6	
1976	28.1		0.0		40.7		7.0		0.1		0.0		75.9	
1977	30.7		0.0		59.0		11.1		0.3		0.0		101.1	
1978	15.9		0.0		46.1		10.9		0.2		0.0		73.1	
1979	11.4		0.0		32.2		6.0		0.1		0.0		49.7	
1980	2.6		0.0		17.2		2.7		0.0		0.0		22.6	
1981	2.8		0.0		14.3		3.0		0.0		0.0		20.1	
1982	0.9	11.4		3.7			1.7		0.0		0.0		17.6	
1983	0.8	13.6		4.1			1.9		0.0		0.0		20.4	
1984	0.5	15.2		4.0			2.6		0.0		0.0		22.3	
1985	0.5	13.3		2.7			1.8		0.0		0.0		18.4	
1986	0.4	5.7		1.1			1.0		0.0		0.0		8.2	

Table R5 (cont.). Gulf of Maine haddock discards (mt) and coefficients of variation (CV) for the selected fleets, 1964 – 2006. Discards from 1989 – 2006 were derived using a combined ratio estimator of Gulf of Maine haddock discards to the retained amount of all species. Discards from 1964 – 1988 were derived using equation 1; no estimates of precision are available for these values.

Year	Longline, benthic		Otter trawl, bottom, large mesh ( $\geq 5.5"$ )		Otter trawl, bottom, small mesh ( $< 5.5"$ )		Gillnet, sink		Otter trawl, paired- midwater		Otter trawl, midwater		Total	
	discards (mt)	CV	discards (mt)	CV	discards (mt)	CV	discards (mt)	CV	discards (mt)	CV	discards (mt)	CV	discards (mt)	CV
1987	0.1		0.9		0.1		0.2		0.0		0.0		1.2	
1988	0.1		1.0		0.1		0.3		0.0		0.0		1.5	
1989			5.8	0.91	0.0	0.97	2.9	0.50					8.7	0.62
1990			0.5	1.10	0.0		1.9	0.43					2.4	0.41
1991	0.4	1.20	2.3	0.62	0.0		1.4	0.31					4.1	0.38
1992	0.0		18.0	0.66	0.0		1.0	0.25					19.1	0.62
1993	0.0		26.3	0.53	0.0		3.4	0.34					29.7	0.47
1994			85.8	0.56			7.6	0.44					93.5	0.52
1995			121.4	0.37	0.5	0.34	5.7	0.39			0.0		127.6	0.36
1996			85.9	0.69	2.4	2.05	18.3	0.50					106.5	0.57
1997			368.0	1.65	0.0		0.3	1.08					368.2	1.65
1998			20.9	0.42			3.2	0.64					24.1	0.37
1999			1.3	1.47	0.2	0.47	1.3	0.53					2.9	0.70
2000			30.0	0.59			7.9	0.44			0.0		37.9	0.47
2001			13.1	0.51	8.3	0.71	5.7	0.31					27.1	0.34
2002			11.1	0.32	0.8	0.53	11.8	0.36					23.6	0.24
2003	5.3	0.46	11.2	0.20	0.3	0.56	5.8	0.19					22.6	0.16
2004	0.5	0.37	20.1	0.30	0.7	0.89	3.9	0.20	0.0	0.09	1.5	0.95	26.6	0.23
2005	17.0	0.26	14.5	0.21	0.1	0.54	4.5	0.14	0.6	0.14	0.6	1.16	37.4	0.15
2006	7.1	0.35	38.8	0.50	0.2	0.43	3.2	0.23	0.0		0.0	1.51	49.4	0.40
Average	4.3	0.5	48.6	0.6	0.9	0.8	5.0	0.4	0.2	0.1	0.4	1.2	56.2	0.48

Table R6. Recreational landings and releases of Gulf of Maine haddock, 1981 – 2006. The weight of recreational landings from 1981 to 2001 were estimated from the total numbers multiplied by the average weight of individually sampled fish from 1981 to 2001.

Year	Annual length samples (numbers)	Estimated recreational landings, A + B1 (numbers)	Estimated recreational releases, B2 (numbers)	Estimated recreational landings (mt)
1981	13	22,990	0	36.3
1982	2	19,531	122	30.9
1983	10	36,455	0	57.6
1984	16	31,277	1,687	49.4
1985	7	19,417	92	30.7
1986	0	34,777	432	55.0
1987	6	18,765	0	29.7
1988	2	7,630	2,970	12.1
1989	3	5,995	5,134	9.5
1990	0	1,836	278	2.9
1991	0	242	0	0.4
1992	0	0	0	0.0
1993	0	336	0	0.5
1994	4	2,385	1,720	3.8
1995	153	110,818	43,469	175.1
1996	25	4,190	8,597	6.6
1997	21	20,022	15,733	31.6
1998	62	28,161	9,550	44.5
1999	32	12,128	16,673	19.2
2000	34	80,735	101,016	127.6
2001	25	120,422	112,326	190.3
2002	119	83,283	171,955	165.9
2003	210	119,788	260,881	191.8
2004	928	278,497	142,426	429.6
2005	1,711	444,739	116,168	717.1
2006	1,171	277,858	164,196	503.9

Table R7. Summary of United States Gulf of Maine haddock number of fish lengths measured from the commercial fishery by market category and quarter, 1965 – 2006.

Year	Large				Scrod				Unclassified				Total
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	
1969		93	59				282	92					526
1970													0
1971	86			101				82					269
1972			74	115									189
1973	99		627					205					931
1974					207	47							254
1975					64	100							164
1976	30						74	108					212
1977		197	358		382	511	481	569					2498
1978	149	35	200		223	322	179	203					1311
1979	195		124	100	114			66					599
1980		319	102		51	175	257	201					1105
1981		52	257	638	53	358	514	381					2253
1982	103		1361	104	473	53	273	154				87	2608
1983	249	868	1317	496	312	308	340	203		102			4195
1984		79	828	391	187	94	139	113					1831
1985	347	597	573	536	353	202	298	84					2990
1986	283	234	789	271	181	242	207	204					2411
1987	214	102	515	405	162	79	75	136					1688
1988	91		100	202	261	50	42						746
1989			65	118	99			129					411
1990	34			100	41	50		50					275
1991		146	216	213	57		179	212					1023
1992	121			19	107		53	111					411
1993					103	56	125		54				338
1994		100	52	297				219					668
1995	62				194								256
1996	77			427		92		100					696
1997	120	255	497	355		124	358	147					1856
1998	309	111	78	313	689	49	156	35					1740
1999	117		300	211			214	102					944
2000	488	313	339	107	414	259	105	287					2312
2001	528	93	207	579	353	108	66	847					2781
2002	729	210		262	348	143	247	161					2100
2003	792	348	1282	1043	485	216	716	513					5395
2004	1898	942	101	601	1021	1085	262	451					6361
2005	1313	325	573	752	661	449	733	769					5575
2006	1193	687	453	617	928	535	569	514					5496
Average	351	271	423	337	281	216	255	231	0	54	102	87	1620

Table R8. Summary of United States Gulf of Maine haddock number of fish ages measured from the commercial fishery by market category and quarter, 1965 – 2006.

Year	Large				Scrod				Unclassified				Total
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	
1965		20	119	57		15	90	45					346
1966		20	39			15	45	14					133
1967	58	78		39	30	87			14				326
1968	20	59		20	30				15				144
1969		20	15				31	15					81
1970													
1971													
1972			20	20									40
1973	20		38					40					98
1974					40	20							60
1975					15					25			40
1976	19						20	35					74
1977		40	57		112	155	175	220					759
1978	40	20	39		80	115	50	49					393
1979	48		25	45	30								164
1980		58	20		17	39	68	46					248
1981		15	61	147	14	105	124	80					546
1982	20		284	21	103	14	75	45				25	587
1983	65	214	225	110	90	90	77	43					914
1984		21	229	94	47	31	47	31					500
1985	95	140	135	148	95	64	95	10					782
1986	49	61	149	55	54	75	58	61					562
1987	36	24	125	105	40	14	28	45					417
1988	18		17	39	86		15						175
1989			16	15	58			27					116
1990	28			22	15	16		15					96
1991		32	37	40	16		80	47					252
1992	20			18	20		15	65					138
1993					20	23	49			19			111
1994		26	21	124				72					243
1995	28				58								86
1996	25			91		13		18					147
1997	23	79	130	81		22	69	56					460
1998	45	24	23	145	82	21	41	21					402
1999	13		76	70	20		67	35					281
2000	136	88	98	38	148	93	57	91					749
2001	143	33	71	177	99	39	18	197					777

Table R8 (cont.). Summary of United States Gulf of Maine haddock number of fish ages measured from the commercial fishery by market category and quarter, 1965 – 2006.

Year	Large				Scrod				Unclassified				Total
	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	
2002	264	71		92	159	47	24	66					723
2003	250	88	431	274	161	90	308	199					1801
2004	500	142		41	283	206	33	41					1246
2005	251	48	211	314	157	122	274	246					1623
2006	634	165	287	255	444	268	294	225					2572
Average	110	63	107	93	85	69	83	66	0	21	0	25	480

Table R9. Commercial landings (numbers) at age of Gulf of Maine haddock, 1977 to 2006.

<b>Year</b>	<b>Age 0</b>	<b>Age 1</b>	<b>Age 2</b>	<b>Age 3</b>	<b>Age 4</b>	<b>Age 5</b>	<b>Age 6</b>	<b>Age 7</b>	<b>Age 8</b>	<b>Age 9<sup>+</sup></b>
1977	0	43,819	1,747,221	51,098	364,994	215,034	143,583	4,784	1,595	6,307
1978	0	0	337,730	1,958,372	181,197	320,312	154,563	32,035	0	4,615
1979	0	7,505	81,405	613,455	1,348,833	200,535	105,464	32,400	23,773	0
1980	0	0	861,575	109,761	754,926	1,235,766	165,436	134,098	11,541	25,286
1981	0	0	1,458,310	641,347	266,750	356,772	498,194	69,111	96,785	12,109
1982	0	67,019	440,655	1,245,149	510,438	80,542	225,104	399,977	89,564	59,552
1983	0	0	6,356	595,430	712,654	588,867	109,148	184,032	250,993	86,804
1984	0	0	44,743	31,968	409,781	173,120	247,349	43,114	48,932	99,747
1985	0	0	16,551	236,058	62,202	267,107	107,855	173,355	34,658	37,578
1986	0	0	0	153,670	287,737	63,370	97,494	73,822	87,970	11,383
1987	0	0	2,320	16,216	90,376	48,893	33,148	51,938	37,461	17,095
1988	0	0	0	12,730	9,775	52,904	38,249	9,021	20,529	4,281
1989	0	0	15,681	3,416	48,499	16,489	21,232	16,099	1,730	841
1990	0	0	1,867	133,316	1,780	24,052	17,695	28,242	3,399	0
1991	0	0	26,620	47,727	61,648	17,650	19,161	12,999	2,718	2,153
1992	0	0	7,377	88,913	36,284	23,326	2,390	2,325	0	1,140
1993	0	0	11,729	25,398	29,789	17,584	5,866	6,374	0	0
1994	0	0	5,295	29,463	9,363	1,688	6,946	4,519	1,034	571
1995	0	0	1,796	5,690	30,777	9,394	4,989	5,019	3,038	2,783
1996	0	0	2,410	53,332	52,961	14,010	4,300	6,094	5,293	753
1997	0	0	2,410	82,679	104,599	53,409	12,733	4,196	1,023	1,208
1998	0	0	11,805	19,964	111,328	171,499	50,298	16,415	7,258	7,173
1999	0	0	261	41,439	60,510	89,797	60,452	30,602	6,713	6,043
2000	0	0	3,600	27,855	84,244	53,278	114,707	49,802	26,339	13,913
2001	0	0	7,800	148,018	101,289	72,357	67,577	64,367	31,783	20,692
2002	0	0	0	11,009	176,520	89,878	90,841	28,527	53,291	56,747
2003	0	0	0	2,322	29,840	344,851	70,203	51,501	18,023	60,350
2004	0	0	0	2,074	19,757	42,925	344,739	52,582	24,629	40,917
2005	0	0	0	1,369	18,264	41,911	68,736	310,682	35,843	53,820
2006	0	0	0	8,020	328	20,450	35,445	39,705	200,654	40,935

Table R10. Coefficients of variation (CV) at age for Gulf of Maine haddock commercial landings, 1984 to 2006. \*Note: CVs can not be determined for landings before 1984 because individual biological samples can not be identified in the database.

Year	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14	Age 15
1984	0.23	0.09	0.09	0.11	0.03	0.09	0.12	0.09	0.27	0.53	0.17	0.25		
1985	0.18	0.10	0.16	0.08	0.11	0.05	0.11	0.16	0.18	1.28	0.79			
1986		0.07	0.06	0.05	0.04	0.04	0.08	0.17	0.24					
1987	0.41	0.19	0.07	0.05	0.07	0.05	0.08	0.10	0.19	0.46				
1988		0.34	0.23	0.31	0.46	0.31	0.45	0.55	0.65					
1989	0.79	1.02	0.43	0.41	0.38	0.32	0.93	1.13						
1990	0.85	0.24	1.07	0.50	0.48	0.52	1.04							
1991	0.54	0.26	0.13	0.25	0.23	0.24	0.52	0.85						
1992	0.89	0.19	0.40	0.57	0.73	1.01		1.43						
1993	0.18	0.18	0.19	0.25	0.28	0.49								
1994	0.17	0.10	0.27	0.38	0.31	0.23	0.47	1.09	1.13	0.88				
1995		0.74	0.14	0.44	0.42	0.35	0.44	8.11	0.99	0.61				
1996	0.85	0.26	0.24	0.34	0.31	0.45	0.76	1.06						
1997	0.99	0.12	0.14	0.13	0.26	0.24	0.37	0.35	0.77	1.15				
1998	0.83	0.30	0.14	0.11	0.19	0.36	0.37	0.61	1.24	1.38				
1999		0.28	0.21	0.20	0.23	0.22	0.37	0.55		1.12	0.97	1.43		
2000	0.54	0.24	0.16	0.12	0.11	0.17	0.26	0.52	0.65		0.87	0.70	0.77	
2001	0.45	0.10	0.10	0.16	0.11	0.15	0.22	0.37	0.53	0.92			1.10	
2002		0.44	0.08	0.15	0.13	0.24	0.17	0.21	0.28	0.48	1.36			
2003	0.81	0.19	0.05	0.11	0.14	0.19	0.15	0.18	0.46	0.40	0.75	1.28		
2004		0.68	0.47	0.17	0.04	0.12	0.19	0.26	0.28	0.31	0.46	0.99		
2005	0.73	0.27	0.15	0.10	0.03	0.15	0.17	0.27	0.29	0.27	0.73	1.21		
2006		0.25	0.76	0.16	0.13	0.09	0.04	0.12	0.18	0.30	0.22	0.33	0.55	1.34

Table R11. Summary of Gulf of Maine haddock length and age measurements taken of United States commercial discards by quarter, 1989 – 2006.

Year	Number of individual lengths					Number of individual ages				
	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual Total	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Annual Total
1989		2		8	10					
1990										
1991			1		1					
1992	17		11	13	41				9	9
1993	48	10	19	16	93			3		3
1994	92	4	1	33	130					
1995	178	7	38	39	262	2	4	7	6	19
1996	39	44	8	70	161	20	24	4	45	93
1997	68	1	2		71	42				42
1998		2		2	4				1	1
1999			5	9	14			5	4	9
2000	6		6	5	17					
2001	23	7	1	2	33					
2002	35		65	20	120					
2003	121	81	49	99	350					
2004	57	66	215	195	533					
2005	209	86	177	268	740					
2006	332	85	48	6	471					

Table R12. Commercial discards (numbers) at age of Gulf of Maine haddock, 1977 to 2006.

<b>Year</b>	<b>Age 0</b>	<b>Age 1</b>	<b>Age 2</b>	<b>Age 3</b>	<b>Age 4</b>	<b>Age 5</b>	<b>Age 6</b>	<b>Age 7</b>	<b>Age 8</b>	<b>Age 9<sup>+</sup></b>
1977	10,539	640,666	64,405	0	0	0	0	0	0	0
1978	15,274	4,700	147,127	1,797	0	0	0	0	0	1,469
1979	128,449	171,388	16,495	3,299	0	0	0	0	0	0
1980	79,633	126,725	3,805	244	0	0	0	0	0	0
1981	3,935	171,168	1,967	0	0	0	0	0	0	0
1982	212,189	6,241	17,831	892	0	0	0	0	0	0
1983	2,903	86,799	11,176	8,709	0	0	0	0	0	0
1984	0	11,859	45,084	1,020	2,001	0	0	0	0	0
1985	216	3,275	8,823	22,666	0	0	0	0	0	0
1986	10,274	20,549	0	0	0	0	0	0	0	0
1987	14,397	7,998	0	0	0	0	0	0	0	0
1988	0	18,159	0	0	0	0	0	0	0	0
1989	0	322	678	72	164	0	0	0	0	0
1990	3,225	3,225	0	1,290	0	0	0	0	0	0
1991	6,305	5,405	1,501	300	0	0	0	0	0	0
1992	3,169	13,348	7,183	3,118	70	0	0	0	0	0
1993	5,635	4,435	6,380	1,119	649	85	229	23	138	213
1994	14,238	21,212	4,196	5,056	922	356	744	479	62	96
1995	169	9,206	10,745	7,719	2,663	290	164	107	0	0
1996	14,836	3,078	10,088	26,694	3,211	542	120	121	69	0
1997	13	234	466	7,088	9,987	1,940	360	120	44	20
1998	212,590	26,296	27,236	3,040	9,278	9,793	53	0	0	26
1999	55,639	418,801	33,933	12,345	3,112	3,053	5,547	2,276	1,762	1,593
2000	5,085	25,746	224,018	67,726	7,940	1,090	2,007	452	208	21
2001	7,384	9,801	69,791	131,472	14,400	2,605	2,793	1,688	32	0
2002	47	3,936	2,340	12,120	31,653	3,229	523	22	93	113
2003	0	124	4,107	1,062	3,764	15,072	1,549	287	238	132
2004	511	11,979	568	7,626	1,628	4,421	18,738	1,577	601	722
2005	58	350	20,746	1,307	6,844	5,681	5,462	13,469	774	669
2006	3,577	6,482	1,119	24,672	2,617	2,562	1,067	1,915	6,357	244

Table R13. Recreational landings (numbers) at age of Gulf of Maine haddock, 1977 to 2006.

<b>Year</b>	<b>Age 0</b>	<b>Age 1</b>	<b>Age 2</b>	<b>Age 3</b>	<b>Age 4</b>	<b>Age 5</b>	<b>Age 6</b>	<b>Age 7</b>	<b>Age 8</b>	<b>Age 9<sup>+</sup></b>
1977	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	0	0	0	0	0	0	0
1981	0	0	5,309	4,216	2,129	3,191	4,964	1,023	1,564	594
1982	0	0	2,424	10,642	3,479	649	587	1,286	211	253
1983	0	0	638	9,809	11,413	7,470	1,162	1,656	3,092	1,215
1984	0	0	8,447	1,177	8,265	3,051	6,353	863	819	2,303
1985	0	0	651	8,834	1,064	3,429	1,408	2,616	651	763
1986	0	1,199	0	5,899	16,305	2,832	4,192	1,937	1,997	416
1987	0	0	1,321	1,882	6,347	2,600	1,884	2,228	1,219	1,283
1988	0	0		309	302	2,144	1,838	392	2,135	509
1989	0	0	1,129	253	983	1,171	1,157	1,117	86	100
1990	0	0	0	898	0	173	102	357	306	0
1991	0	0	45	91	71	17	12	6	0	0
1992	0	0	0	0	0	0	0	0	0	0
1993	0	0	67	135	83	24	19	3	5	0
1994	0	0	303	1,262	232	192	249	128		20
1995	0	0	18,250	51,658	37,934	1,125	660	531	330	330
1996	0	0	132	1,792	1,532	334	107	150	115	28
1997	0	0	128	6,943	8,254	2,767	978	436	220	295
1998	0	0	1,055	2,224	10,045	11,518	2,093	512	329	386
1999	0	0	0	1,698	1,873	3,602	3,025	1,451	319	159
2000	0	0	604	5,780	20,732	12,795	23,484	11,339	4,641	1,359
2001	0	0	4,363	44,372	26,413	15,760	10,942	10,019	5,538	3,015
2002	0	0	0	426	23,586	16,355	16,417	4,547	10,179	11,775
2003	0	0	8	246	5,184	71,603	16,239	10,346	3,929	12,236
2004	0	342	86	1,395	14,107	33,489	189,118	15,477	11,392	13,093
2005	0	342	1,182	1,718	25,593	40,786	74,517	248,198	23,658	28,739
2006	0	0	0	25,949	772	20,986	33,506	34,838	141,614	20,195

Table R14. Vessel and door types used in the Northeast Fisheries Science Center's spring and autumn bottom trawl surveys where Gulf of Maine haddock were caught and the types of conversion factors applied to the annual indices, 1963 – 2007. Coefficients of 0.82 (Delaware II) and 1.49 (BMV trawl door) were applied to abundance indices and 0.79 (Delaware II) and 1.51 (BMV trawl door) were applied to biomass indices.

Year	Door	Spring survey vessel	Spring conversion factor	Autumn survey vessel	Autumn conversion factor
1963	BMV			Albatross IV	door
1964	BMV			Albatross IV	door
1965	BMV			Albatross IV	door
1966	BMV			Albatross IV	door
1967	BMV			Albatross IV	door
1968	BMV	Albatross IV	door	Albatross IV	door
1969	BMV	Albatross IV	door	Albatross IV	door
1970	BMV	Albatross IV	door	Albatross IV	door
1971	BMV	Albatross IV	door	Albatross IV	door
1972	BMV	Albatross IV	door	Albatross IV	door
1973	BMV	Albatross IV	door	Albatross IV	door
1974	BMV	Albatross IV	door	Albatross IV	door
1975	BMV	Albatross IV	door	Albatross IV	door
1976	BMV	Albatross IV	door	Albatross IV	door
1977	BMV	Albatross IV	door	Delaware II	door
1978	BMV	Albatross IV	door	Delaware II	door
1979	BMV	Albatross IV/Delaware II	door, vessel	Albatross IV/Delaware II	door, vessel
1980	BMV	Delaware II	door, vessel	Delaware II	door
1981	BMV	Delaware II	door, vessel	Albatross IV/Delaware II	door, vessel
1982	BMV	Albatross IV	door	Albatross IV	door
1983	BMV	Albatross IV	door	Albatross IV	door
1984	BMV	Albatross IV	door	Albatross IV	door
1985	Polyvalent	Albatross IV		Albatross IV	
1986	Polyvalent	Delaware II	vessel	Albatross IV	
1987	Polyvalent	Albatross IV		Albatross IV	
1988	Polyvalent	Delaware II	vessel	Albatross IV	
1989	Polyvalent	Delaware II	vessel	Delaware II	vessel
1990	Polyvalent	Delaware II	vessel	Delaware II	vessel
1991	Polyvalent	Albatross IV		Delaware II	vessel
1992	Polyvalent	Albatross IV		Albatross IV	
1993	Polyvalent	Delaware II	vessel	Delaware II	vessel
1994	Polyvalent	Albatross IV		Albatross IV	
1995	Polyvalent	Albatross IV		Albatross IV	
1996	Polyvalent	Albatross IV		Albatross IV	
1997	Polyvalent	Albatross IV		Albatross IV	
1998	Polyvalent	Albatross IV		Albatross IV	
1999	Polyvalent	Albatross IV		Albatross IV	
2000	Polyvalent	Albatross IV		Albatross IV	
2001	Polyvalent	Albatross IV		Albatross IV	
2002	Polyvalent	Delaware II	vessel	Albatross IV	
2003	Polyvalent	Albatross IV		Albatross IV	
2004	Polyvalent	Albatross IV		Albatross IV	
2005	Polyvalent	Albatross IV		Albatross IV	
2006	Polyvalent	Albatross IV		Albatross IV	
2007	Polyvalent	Albatross IV		Albatross IV	

Table R15. Northeast Fisheries Science Center (NEFSC) spring and autumn survey indices of abundance (stratified mean numbers/tow) and biomass (stratified mean kg/tow) for Gulf of Maine haddock with, 1968 – 2007.

Year	NEFSC spring numbers/tow	NEFSC spring numbers/tow standard error	NEFSC spring weight (kg)/tow	NEFSC spring weight (kg)/tow standard error	NEFSC autumn numbers/ tow	NEFSC autumn numbers/tow standard error	NEFSC autumn weight (kg)/tow	NEFSC autumn weight (kg)/tow standard error
1968	6.066	1.907	8.107	2.194	69.549	20.456	50.697	8.362
1969	3.719	0.802	6.607	1.523	14.176	5.432	18.386	3.533
1970	0.906	0.232	1.784	0.482	17.434	6.342	17.731	3.991
1971	0.878	0.436	2.523	1.203	10.742	3.786	13.103	3.962
1972	0.862	0.329	0.867	0.555	12.186	3.092	16.871	4.444
1973	1.312	0.347	1.598	0.651	8.564	1.430	17.307	2.900
1974	1.437	0.611	1.059	0.472	5.451	1.373	12.721	3.055
1975	2.770	0.815	3.482	1.650	2.918	0.672	7.354	1.663
1976	8.326	3.015	6.350	2.487	2.880	1.010	8.159	2.863
1977	6.799	2.299	6.725	2.797	1.984	0.504	3.036	1.101
1978	1.356	0.621	1.434	0.454	4.165	0.905	8.583	2.905
1979	2.890	0.691	3.948	0.926	2.687	1.642	3.347	1.131
1980	2.212	0.975	2.673	1.351	5.533	1.517	8.616	2.856
1981	3.613	0.958	3.545	0.846	6.035	1.496	8.040	2.365
1982	2.047	0.732	2.555	0.967	8.296	2.878	8.752	2.624
1983	3.678	1.684	3.567	1.721	9.775	1.773	21.658	4.299
1984	1.095	0.502	1.144	0.532	6.174	1.300	15.567	3.523
1985	1.773	0.739	1.882	0.618	7.152	2.666	9.835	2.543
1986	0.707	0.362	1.284	0.696	4.456	0.878	10.874	2.645
1987	0.092	0.038	0.063	0.036	2.627	1.000	4.164	1.301
1988	0.187	0.108	0.301	0.199	2.598	0.820	5.219	1.613
1989	0.083	0.069	0.125	0.115	1.697	0.513	3.893	1.164
1990	0.024	0.015	0.000	0.000	4.079	1.780	6.149	1.994
1991	0.074	0.044	0.066	0.046	0.623	0.285	1.392	0.585
1992	0.193	0.125	0.271	0.268	1.035	0.354	2.645	0.755
1993	0.450	0.229	0.200	0.158	0.335	0.233	1.476	1.126
1994	0.402	0.151	0.253	0.105	0.283	0.119	0.631	0.335
1995	0.806	0.414	0.350	0.172	0.145	0.059	0.432	0.168
1996	0.305	0.105	0.338	0.129	0.142	0.092	0.120	0.091
1997	1.935	0.848	1.222	0.691	0.211	0.128	0.091	0.062
1998	0.197	0.085	0.112	0.054	0.866	0.709	0.472	0.453
1999	4.267	1.873	1.108	0.438	0.325	0.150	0.217	0.207
2000	3.610	1.620	1.815	0.833	0.977	0.598	1.099	0.501
2001	2.364	1.547	3.205	2.306	2.407	0.970	3.543	1.632
2002	5.704	3.222	2.793	0.991	2.688	1.071	2.424	0.752
2003	3.191	0.871	3.908	1.196	3.130	1.735	2.917	1.321
2004	1.061	0.404	1.199	0.530	6.730	2.116	4.910	1.254
2005	0.862	0.383	0.971	0.508	16.589	8.290	14.032	6.095
2006	3.151	1.536	2.661	1.188	9.960	2.918	11.981	3.326
2007	0.771	0.315	0.675	0.262	3.920	1.491	4.835	1.746
Average	2.054	0.801	2.069	0.809	4.733	1.147	5.359	1.367

Table R16. Summary of the number of individual length and age measurements taken during the Northeast Fisheries Science Center spring and autumn bottom trawl surveys, 1963 – 2007.

Year	Lengths		Ages	
	Spring	Autumn	Spring	Autumn
1963		2347		320
1964		412		140
1965		609		142
1966		356		140
1967		316		162
1968	189	260	108	232
1969	134	161	94	148
1970	36	74	36	69
1971	39	72	38	50
1972	37	53	34	51
1973	50	142	44	112
1974	61	114	26	58
1975	280	365	132	175
1976	919	363	154	164
1977	498	660	150	181
1978	68	887	29	78
1979	219	603	19	145
1980	105	331	59	117
1981	199	151	115	28
1982	106	101	76	64
1983	159	102	64	99
1984	35	59	34	59
1985	92	194	65	137
1986	27	29	26	29
1987	5	35	5	27
1988	10	13	9	12
1989	10	22	10	21
1990	2	9	1	9
1991	4	9	4	6
1992	9	11	9	8
1993	25	64	19	34
1994	24	16	20	10
1995	31	55	21	33
1996	10	91	10	66
1997	98	115	60	74
1998	11	225	11	90
1999	278	517	77	216
2000	207	809	83	157
2001	209	468	72	184
2002	333	151	119	98
2003	236	233	118	130
2004	56	312	41	113
2005	49	197	33	117
2006	232	288	95	167
2007	48	251	38	125

Table R17. Stratified mean numbers-at-age per tow of Gulf of Maine haddock from the Northeast Fisheries Science Center (NEFSC) spring survey, 1968 – 2007. Indices have been corrected to account for changes in catchability due to changes in research vessels and doors.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9 <sup>+</sup>
1968	0.000	0.000	0.000	0.051	0.301	4.433	0.893	0.134	0.112	0.142
1969	0.000	0.000	0.000	0.054	0.019	0.263	2.526	0.785	0.029	0.043
1970	0.000	0.000	0.000	0.000	0.000	0.000	0.143	0.612	0.092	0.059
1971	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.026	0.637	0.189
1972	0.000	0.584	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.278
1973	0.000	0.129	0.784	0.000	0.054	0.000	0.000	0.000	0.000	0.345
1974	0.000	0.900	0.088	0.333	0.000	0.000	0.000	0.000	0.016	0.101
1975	0.000	0.030	1.958	0.152	0.380	0.000	0.203	0.000	0.000	0.048
1976	0.000	5.114	0.124	1.734	0.176	0.942	0.067	0.033	0.000	0.136
1977	0.000	1.158	3.268	0.049	1.339	0.407	0.578	0.000	0.000	0.000
1978	0.000	0.085	0.716	0.333	0.030	0.192	0.000	0.000	0.000	0.000
1979	0.000	0.371	0.314	0.400	1.379	0.233	0.194	0.000	0.000	0.000
1980	0.000	1.053	0.152	0.171	0.455	0.318	0.025	0.000	0.000	0.037
1981	0.000	1.181	0.993	0.607	0.213	0.356	0.160	0.025	0.038	0.038
1982	0.000	0.045	0.433	0.892	0.465	0.147	0.066	0.000	0.000	0.000
1983	0.143	1.352	0.137	1.236	0.319	0.306	0.000	0.163	0.000	0.022
1984	0.000	0.019	0.570	0.054	0.299	0.108	0.000	0.000	0.045	0.000
1985	0.000	0.042	0.280	1.095	0.058	0.170	0.059	0.050	0.020	0.000
1986	0.000	0.051	0.000	0.121	0.403	0.000	0.036	0.073	0.023	0.000
1987	0.000	0.036	0.025	0.031	0.000	0.000	0.000	0.000	0.000	0.000
1988	0.000	0.043	0.000	0.000	0.015	0.119	0.010	0.000	0.000	0.000
1989	0.000	0.000	0.036	0.012	0.000	0.012	0.012	0.012	0.000	0.000
1990	0.012	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1991	0.000	0.014	0.007	0.052	0.000	0.000	0.000	0.000	0.000	0.000
1992	0.000	0.085	0.000	0.000	0.109	0.000	0.000	0.000	0.000	0.000
1993	0.000	0.261	0.146	0.000	0.000	0.029	0.015	0.000	0.000	0.000
1994	0.000	0.074	0.182	0.122	0.024	0.000	0.000	0.000	0.000	0.000
1995	0.000	0.441	0.240	0.073	0.030	0.000	0.000	0.000	0.023	0.000
1996	0.000	0.000	0.037	0.146	0.123	0.000	0.000	0.000	0.000	0.000
1997	0.000	0.775	0.231	0.239	0.592	0.076	0.022	0.000	0.000	0.000
1998	0.000	0.080	0.046	0.000	0.062	0.009	0.000	0.000	0.000	0.000
1999	0.000	3.724	0.087	0.162	0.029	0.227	0.039	0.000	0.000	0.000
2000	0.000	1.037	1.188	0.968	0.145	0.084	0.053	0.136	0.000	0.000
2001	0.000	0.073	0.131	1.040	0.525	0.167	0.227	0.065	0.048	0.090
2002	0.000	3.299	0.207	0.605	1.418	0.081	0.036	0.022	0.036	0.000
2003	0.000	0.359	0.203	0.093	0.109	1.990	0.204	0.144	0.036	0.054
2004	0.000	0.115	0.000	0.154	0.033	0.095	0.621	0.029	0.000	0.015
2005	0.000	0.010	0.172	0.000	0.070	0.083	0.225	0.274	0.000	0.029
2006	0.000	0.179	0.092	1.678	0.272	0.104	0.022	0.211	0.548	0.047
2007	0.000	0.156	0.085	0.028	0.252	0.000	0.028	0.029	0.034	0.159
Average 1968 - 2007	0.004	0.572	0.323	0.317	0.242	0.274	0.162	0.071	0.043	0.046

Table R18. Stratified mean numbers-at-age per tow of Gulf of Maine haddock from the Northeast Fisheries Science Center (NEFSC) autumn survey, 1963 – 2007. Indices have been corrected to account for changes in catchability due to changes in research vessels and doors.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9 <sup>+</sup>
1963	35.602	12.183	1.704	3.012	6.942	4.938	1.669	1.318	1.041	1.142
1964	0.081	5.904	1.848	0.706	0.975	1.820	1.754	0.984	0.000	0.103
1965	0.054	0.367	7.991	5.064	0.253	1.450	1.205	0.663	0.333	0.054
1966	0.019	0.000	0.525	6.597	2.181	0.284	0.616	0.403	0.083	0.034
1967	0.000	0.000	0.000	1.542	7.995	1.801	0.528	0.125	0.149	0.046
1968	0.000	0.000	0.000	0.000	0.193	6.265	1.452	0.217	0.319	0.117
1969	0.000	0.000	0.000	0.037	0.028	0.037	4.119	0.931	0.138	0.161
1970	0.000	0.048	0.000	0.000	0.000	0.126	0.136	1.946	0.606	0.057
1971	0.268	0.000	0.000	0.000	0.016	0.000	0.122	0.169	2.029	0.276
1972	0.000	1.190	0.000	0.024	0.000	0.000	0.000	0.000	0.000	0.770
1973	1.129	0.022	0.960	0.000	0.356	0.026	0.022	0.038	0.022	1.592
1974	0.022	1.660	0.209	0.429	0.000	0.000	0.000	0.000	0.000	0.368
1975	0.888	0.227	1.916	0.558	1.388	0.000	0.045	0.045	0.000	0.466
1976	1.633	1.794	0.077	1.275	0.149	0.902	0.000	0.189	0.000	0.016
1977	0.104	3.085	3.401	0.137	1.028	0.192	0.255	0.000	0.000	0.094
1978	0.174	0.087	1.716	5.523	0.201	0.640	1.204	0.126	0.000	0.104
1979	0.781	0.421	0.084	1.123	2.854	0.509	0.326	0.063	0.000	0.013
1980	3.953	0.509	0.320	0.000	0.298	1.068	0.650	0.157	0.105	0.093
1981	0.000	0.614	0.562	1.013	0.314	0.855	0.681	0.170	0.183	0.064
1982	0.386	0.056	0.682	0.855	0.306	0.055	0.000	0.112	0.048	0.128
1983	0.000	0.557	0.053	0.638	0.603	0.312	0.172	0.068	0.161	0.034
1984	0.000	0.202	0.541	0.000	0.282	0.000	0.408	0.000	0.034	0.228
1985	0.000	0.089	0.471	2.725	0.017	0.182	0.150	0.395	0.000	0.051
1986	0.000	0.015	0.000	0.069	0.351	0.085	0.018	0.025	0.059	0.000
1987	0.029	0.000	0.127	0.114	0.190	0.061	0.238	0.146	0.000	0.130
1988	0.000	0.000	0.000	0.032	0.023	0.101	0.000	0.041	0.137	0.000
1989	0.000	0.059	0.059	0.019	0.012	0.031	0.052	0.052	0.000	0.000
1990	0.009	0.024	0.000	0.056	0.000	0.000	0.000	0.038	0.019	0.000
1991	0.053	0.047	0.000	0.000	0.042	0.000	0.000	0.000	0.000	0.000
1992	0.043	0.145	0.000	0.023	0.000	0.000	0.000	0.000	0.000	0.000
1993	0.099	0.467	0.219	0.037	0.030	0.015	0.000	0.000	0.000	0.000
1994	0.206	0.047	0.000	0.000	0.000	0.000	0.000	0.036	0.000	0.036
1995	0.000	0.094	0.604	0.185	0.036	0.036	0.000	0.000	0.000	0.023
1996	0.043	0.115	0.227	1.043	0.618	0.068	0.114	0.070	0.036	0.073
1997	0.214	1.328	0.025	0.378	0.584	0.083	0.075	0.000	0.000	0.000
1998	1.466	0.241	0.431	0.131	0.423	0.297	0.070	0.048	0.025	0.000
1999	0.542	3.231	0.620	0.817	0.278	0.477	0.525	0.131	0.051	0.058
2000	0.333	0.806	11.209	1.604	1.265	0.446	0.618	0.222	0.088	0.000
2001	0.196	0.240	2.288	4.821	0.756	0.866	0.287	0.192	0.271	0.045
2002	0.014	0.121	0.014	0.482	2.521	0.365	0.135	0.000	0.205	0.065
2003	0.853	0.000	0.280	0.073	0.486	2.494	0.350	0.048	0.000	0.150
2004	0.073	0.348	0.029	0.559	0.262	0.812	3.215	0.124	0.168	0.116
2005	0.188	0.110	1.579	0.088	0.143	0.314	0.427	1.117	0.076	0.091
2006	0.230	0.282	0.088	1.762	0.028	0.219	0.107	0.285	0.841	0.068
2007	0.015	1.042	0.850	0.221	2.157	0.066	0.014	0.162	0.122	0.504
Average 1963 - 2007	1.104	0.839	0.927	0.973	0.813	0.629	0.483	0.241	0.163	0.164

Table R19. Mean weight at age (kg) of commercial landings of Gulf of Maine haddock, 1977 to 2006.

<b>Year</b>	<b>Age 0</b>	<b>Age 1</b>	<b>Age 2</b>	<b>Age 3</b>	<b>Age 4</b>	<b>Age 5</b>	<b>Age 6</b>	<b>Age 7</b>	<b>Age 8</b>	<b>Age9<sup>+</sup></b>
1977	0.023	0.145	0.737	1.142	2.014	2.624	3.302	4.664	5.980	5.702
1978	0.022	0.115	0.690	1.219	1.776	2.423	2.950	4.135	4.637	4.599
1979	0.016	0.223	0.771	1.220	1.797	2.247	2.535	2.829	3.293	4.479
1980	0.019	0.153	0.758	1.251	1.873	2.389	3.288	3.376	3.989	4.359
1981	0.033	0.116	0.680	1.489	1.970	2.520	3.280	3.840	4.188	3.786
1982	0.037	0.347	0.635	0.998	2.142	2.560	3.102	3.648	4.260	4.086
1983	0.034	0.124	0.548	1.192	1.732	2.375	2.963	3.379	3.719	4.226
1984	0.044	0.237	0.677	1.219	1.798	2.303	3.158	3.948	4.414	4.091
1985	0.053	0.330	0.907	1.058	1.909	2.356	2.655	3.573	4.116	4.205
1986	0.074	0.372	0.983	1.221	1.456	2.281	2.495	3.051	3.632	4.505
1987	0.025	0.095	1.059	1.299	1.995	2.431	2.618	3.364	4.186	5.181
1988	0.025	0.081	1.154	1.231	1.494	2.654	2.337	3.649	4.894	5.353
1989	0.026	0.257	1.249	1.829	1.665	2.507	2.304	3.378	4.474	4.331
1990	0.026	0.240	0.800	1.515	3.361	2.361	2.962	3.628	3.506	3.852
1991	0.014	0.233	1.316	1.482	2.490	2.960	2.964	3.307	4.245	3.372
1992	0.036	0.206	1.140	1.689	1.915	2.679	2.936	2.918	4.211	2.803
1993	0.029	0.185	0.955	1.385	1.918	2.520	3.213	3.900	4.176	4.607
1994	0.034	0.065	0.979	1.656	2.190	2.737	2.864	3.487	3.540	3.935
1995	0.015	0.068	0.875	1.392	2.024	2.617	3.705	4.550	5.150	5.563
1996	0.070	0.237	0.695	1.181	1.784	2.218	3.107	2.387	2.121	3.190
1997	0.069	0.148	1.169	2.083	1.964	2.503	3.179	3.395	3.922	3.843
1998	0.023	0.219	0.866	1.428	1.808	2.174	2.856	3.378	3.124	3.001
1999	0.047	0.168	0.515	1.188	1.683	1.718	2.009	2.389	3.382	3.456
2000	0.039	0.190	0.544	0.803	1.491	1.831	2.059	2.379	2.617	3.387
2001	0.020	0.199	0.678	1.104	1.440	1.786	2.195	2.240	2.456	2.575
2002	0.074	0.178	0.375	0.964	1.334	1.661	2.200	2.667	2.455	2.751
2003	0.049	0.130	0.516	0.942	1.301	1.531	1.850	2.190	2.519	2.566
2004	0.024	0.164	0.583	0.807	1.374	1.407	1.707	2.090	2.155	2.243
2005	0.099	0.154	0.502	0.895	1.142	1.515	1.524	1.792	2.016	2.380
2006	0.035	0.086	0.453	0.840	0.717	1.434	1.760	1.612	1.786	2.123

Table R20. Mean weight at age (kg) of Gulf of Maine haddock caught in the Northeast Fisheries Science Center's autumn bottom trawl survey, 1963 to 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	Age 14
1963	0.026	0.236	0.789	1.324	1.766	2.321	2.848	3.481	3.546	3.505	4.417			5.461	11.000
1964	0.048	0.204	0.712	1.359	1.924	2.190	2.669	3.286	4.387	4.950	6.507				
1965	0.058	0.176	0.367	0.897	1.784	2.184	2.521	3.301	3.614	4.840					
1966		0.297	0.592	0.901	1.238	2.582	2.874	3.511	3.845	3.513					
1967				0.964	1.275	1.509	2.381	3.440	3.624	3.994					
1968					1.574	1.809	2.282	3.118	3.794	4.132					
1969					1.744	1.553	1.845	2.150	2.722	3.016	5.035	2.799		4.215	
1970		0.216				2.024	2.208	2.455	2.789	5.378	4.377				
1971	0.014					1.831		3.273	3.291	2.933	4.091	4.400			
1972		0.256					2.068			3.291	3.682	4.628			
1973	0.022	0.189	0.673		2.365	3.944		3.736	2.458	3.551	4.126	4.372		5.284	5.572
1974	0.015	0.280	1.206	1.910	3.390			5.483		7.177		4.332			6.915
1975	0.020	0.343	0.897	2.051	2.287		3.268	3.116			5.717	3.842	4.629	4.128	
1976	0.032	0.439	1.333	2.033	2.832	3.224		4.373	5.969	6.959			3.744		
1977	0.075	0.283	0.947	1.878	2.524	3.178	3.238	4.931				3.179		3.990	
1978	0.021	0.399	0.755	1.961	3.287	3.743	4.302	5.772					6.380		5.076
1979	0.024	0.314	1.278	1.859	3.172	4.099	4.311	5.139	6.553			6.805			
1980	0.031	0.330	1.136		2.671	3.535	3.985	3.992	5.071	7.488					
1981		0.274	0.793	1.601	2.467	2.998	3.968	5.449	4.276	7.326	8.696				
1982	0.020	0.311	0.939	1.491	2.420	2.725		4.064	4.721		4.245				
1983	0.073	0.208	0.759	1.608	2.041	2.611	3.792	6.869	4.458						
1984		0.288	0.677	1.026	2.725		3.859	4.721	5.997	3.974					
1985		0.369	0.920	1.135	1.390	2.180	2.420	3.697	5.094	6.194	4.177				
1986		0.554		1.274	1.873	3.061	2.441		4.571						
1987	0.035		1.097	1.594	2.015	2.394	2.889	3.909		4.803					
1988					2.854	2.585	3.053	3.607	4.817	6.079					
1989		0.240	1.115	1.868	2.697	3.964	3.290	4.836							

Table R20 (cont.). Mean weights at age (kg) of Gulf of Maine haddock caught in the Northeast Fisheries Science Center's autumn bottom trawl survey, 1963 to 2007.

<b>Year</b>	<b>Age 0</b>	<b>Age 1</b>	<b>Age 2</b>	<b>Age 3</b>	<b>Age 4</b>	<b>Age 5</b>	<b>Age 6</b>	<b>Age 7</b>	<b>Age 8</b>	<b>Age 9</b>	<b>Age 10</b>	<b>Age 11</b>	<b>Age 12</b>	<b>Age 13</b>	<b>Age 14</b>
1990	0.041	0.284		2.107		2.893		5.737	7.685						
1991	0.026	0.377		1.359	2.835										
1992	0.024	0.358		1.686											
1993	0.015	0.295	0.848	1.362	2.025	2.782									
1994	0.014	0.166						2.918				2.784			
1995		0.256	0.768	1.386	1.864	3.397							7.280		
1996	0.048	0.384	0.695	1.107	1.833	1.996	2.903	3.185	2.808		3.910			3.098	
1997	0.013	0.224	0.642	1.047	2.059	3.676	3.160								
1998	0.020	0.264	0.924	1.881	2.396	2.163	2.927	4.363	3.546						
1999	0.026	0.212	0.638	1.270	1.758	1.649	1.966	1.380	2.147	2.414	3.581				
2000	0.033	0.241	0.600	1.106	1.598	2.393	2.347	2.662	2.261						
2001	0.011	0.130	0.801	1.079	1.415	2.037	2.328	2.855	2.840	2.268					
2002	0.080	0.249	0.486	0.885	1.172	1.622	2.189		2.076	1.611		1.695			
2003	0.020		0.634	1.191	1.253	1.409	1.568	1.354		2.020	2.933				
2004	0.013	0.189	0.517	0.771	1.319	1.223	1.424	2.149	1.440		2.090	1.923			
2005	0.028	0.080	0.449	0.543	0.815	1.188	1.416	1.511	2.233	1.981		2.227	2.582		
2006	0.018	0.194	0.426	0.848	0.673	1.673	1.354	1.463	1.482	2.450	2.967			1.856	
2007	0.011	0.190	0.519	0.786	1.033	1.321	2.125	1.445	1.364	1.639		1.917			

Table R21. Availability of maturity samples for female haddock from the NEFSC spring bottom trawl survey, 1974 – 2007.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9 <sup>+</sup>	Total
1974				9					1	3	13
1975											0
1976		7	1	18	5	30	1	2		4	68
1977		3	42	1	22	5	8				81
1978		2	6	9	1	3					21
1979		2		2	7	1	1				13
1980		4	4	3	8	7	1				27
1981		5	14	12	6	9	6		1	1	54
1982			8	16	11	3	1				39
1983		6	1	17	6	7				3	40
1984		1	8		4	3					16
1985		1	1	24		5	3	1	1	2	38
1986				5	11		1	1	1		19
1987		1	1		1						3
1988		1				1	1				3
1989			1	1			1				3
1990											0
1991		1	2								3
1992		2			3						5
1993		3	3			1					7
1994		2	6	4	1						13
1995		7	4	3					1		15
1996				2	4						6
1997		10	5	3	14	2					34
1998		2	2		2						6
1999		16	2	5	2	6	2				33
2000		8	7	17	3	1	1	1			38
2001			2	16	7	2	2	2	1	2	34
2002		12	7	14	44	3	2		1		83
2003		4	6	2	3	44	6	4		2	71
2004		3		7	1	3	13	1		1	29
2005			3		1	1	5	6			16
2006		5	2	17	5	1	1	5	19	1	56
2007		3	2	1	5		2	1	1	4	19
Total	0	111	140	208	177	138	58	24	27	23	906

Table R22. Maturity ogive for Gulf of Maine haddock females. A single maturity ogive is used for all years.

<b>Year</b>	<b>Age 0</b>	<b>Age 1</b>	<b>Age 2</b>	<b>Age 3</b>	<b>Age 4</b>	<b>Age 5</b>	<b>Age 6</b>	<b>Age 7</b>	<b>Age 8</b>	<b>Age 9<sup>+</sup></b>
1977	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1978	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1979	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1980	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1981	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1982	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1983	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1984	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1985	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1986	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1987	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1988	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1989	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1990	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1991	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1992	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1993	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1994	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1995	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1996	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1997	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1998	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
1999	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
2000	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
2001	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
2002	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
2003	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
2004	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
2005	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00
2006	0.00	0.03	0.25	0.80	0.98	1.00	1.00	1.00	1.00	1.00

Table R23. Summary of An Index Method (AIM) model runs. The first run is identical to the model formulation and data that generated the reference points accepted by the previous Biological Reference Point Working Group (NEFSC 2002).

Run	Model description/formulation	Survey index	p-value	MSY (kmt)	Centered smooth			Current	
					F <sub>MSY</sub>	I <sub>MSY</sub> (kg/tow)	1/2 I <sub>MSY</sub> (kg/tow)	F	I
A	1963 - 2000 (CRD 02-04)	Autumn	0.0004	5.052	0.23	21.85	10.93		
B	1963 - 2000 (updated landings and survey)	Autumn	0.0002	5.052	0.26	19.42	9.71	0.08	4.11
1	1963 - 2006 (landings, recreational, discard)	Autumn	0.0019	5.052	0.23	21.95	10.98	0.29	4.09
2	1977 - 2006 (landings, recreational, discard)	Autumn	0.0011	5.052	0.25	19.82	9.91	0.29	4.09

Table R24. Summary of VPA calibration runs for Gulf of Maine haddock. VPA calibration run12 was selected as the candidate model formulation. \*Note: not all calibration runs are shown.

VPA run description	1	12	2	5	9	10	11
<i>Survey indices</i>							
NEFSC Spring ages	1-9	1-6+	3-8		2-8	1-6	1,2,4,5,6
NEFSC Autumn ages (projected +1)	1-9	1-8+	1-8	1-9	2-8	1-8	1-8
<i>Discards</i>							
1977 - 1988 hindcast	Yes						
1989 - 2006 estimates	Yes						
<i>Recreational catch</i>							
1981 - 2006 MRFSS	Yes						
Estimated ages in t+1	1-8	1-8	1-8	1-8	2-8	1-8	1-8
<b>Diagnostics</b>							
Sum of squares	355.5	311.8	256.0	204.5	258.1	306.8	288.8
Mean squared residuals	0.909	0.899	0.826	0.969	0.822	0.897	0.911
CV t+1, n1	0.69	0.69	0.93	1.01		0.69	0.69
CV t+1, n2	0.49	0.49	0.66	0.71	0.65	0.49	0.49
CV t+1, n3	0.40	0.40	0.47	0.58	0.46	0.40	0.44
CV t+1, n4	0.35	0.35	0.39	0.51	0.39	0.35	0.38
CV t+1, n5	0.41	0.41	0.43	0.53	0.47	0.41	0.41
CV t+1, n6	0.32	0.33	0.35	0.48	0.34	0.32	0.33
CV t+1, n7	0.49	0.57	0.48	0.72	0.48	0.56	0.58
CV t+1, n8	0.33	0.35	0.32	0.46	0.33	0.35	0.37
Min/max CV q NEFSC Spring	0.17 - 0.22	0.17 - 0.21	0.17 - 0.22		0.17 - 0.22	0.18 - 0.22	0.18 - 0.21
Min/max CV q NEFSC Autumn	0.13 - 0.33	0.13 - 0.28	0.13 - 0.29	0.13 - 0.33	0.12 - 0.29	0.13 - 0.29	0.13 - 0.29
<b>Results</b>							
<i>Stock numbers</i>							
2007 t+1, n1	1695	1748	2459	2375		1733	1721
2007 t+1, n2	1193	1229	1654	1618	1077	1219	1211
2007 t+1, n3	277	285	355	452	367	283	316
2007 t+1, n4	2181	2248	3334	3287	2499	2230	1851
2007 t+1, n5	196	202	138	76	166	201	199
2007 t+1, n6	458	532	331	377	327	471	474
2007 t+1, n7	81	91	90	76	85	84	84
2007 t+1, n8	235	317	306	231	276	312	293
2007 t+1, n9 <sup>+</sup>	878	1134	1102	853	1004	1101	1048
<i>Fishing mortality</i>							
2006 F3	0.02	0.02	0.02	0.02	0.02	0.02	0.03
2006 F4	0.02	0.02	0.02	0.04	0.02	0.02	0.02
2006 F5	0.08	0.07	0.11	0.10	0.12	0.08	0.08
2006 F6	0.58	0.53	0.53	0.61	0.56	0.56	0.56
2006 F7	0.26	0.20	0.20	0.26	0.22	0.20	0.21
2006 F8	0.35	0.28	0.29	0.36	0.31	0.29	0.30
2006 F4-8	0.23	0.22	0.22	0.27	0.25	0.23	0.23
<i>Biomass</i>							
2006 mean biomass	6136	7021	7677	7025	6509	6812	6336
2006 SSB	5291	6345	6560	5848	5798	6149	5777

Table R25. Gulf of Maine haddock January 1 stock size (000's) at age estimated from the VPA, 1977 to 2007.

<b>Year</b>	<b>Age 0</b>	<b>Age 1</b>	<b>Age 2</b>	<b>Age 3</b>	<b>Age 4</b>	<b>Age 5</b>	<b>Age 6</b>	<b>Age 7</b>	<b>Age 8</b>	<b>Age 9<sup>+</sup></b>	<b>Total</b>
1977	2,382	6,863	13,864	1,889	2,204	593	462	5	5	20	28,287
1978	8,799	1,940	5,000	9,711	1,500	1,474	291	249	0	17	28,981
1979	8,666	7,190	1,584	3,655	6,177	1,064	917	99	175	0	29,527
1980	4,981	6,979	5,725	1,209	2,434	3,837	690	656	51	113	26,675
1981	748	4,006	5,599	3,904	890	1,310	2,023	415	415	54	19,364
1982	2,207	609	3,125	3,258	2,612	485	747	1,201	276	184	14,704
1983	1,013	1,615	432	2,142	1,531	1,674	324	407	620	215	9,973
1984	243	827	1,244	337	1,198	598	831	165	165	339	5,947
1985	340	199	666	930	245	601	330	451	96	104	3,962
1986	184	278	160	522	519	144	247	171	210	27	2,462
1987	765	141	208	131	283	150	58	110	72	34	1,952
1988	564	613	108	167	91	144	76	16	41	9	1,829
1989	433	462	486	89	125	65	68	26	4	2	1,760
1990	426	354	378	382	69	58	37	36	6	0	1,746
1991	770	346	287	308	190	55	25	14	3	3	2,001
1992	1,649	625	278	210	208	100	29	3	0	8	3,110
1993	2,659	1,347	499	215	88	138	61	22	1	1	5,031
1994	3,427	2,172	1,099	392	151	45	97	44	12	8	7,447
1995	1,570	2,793	1,759	891	289	115	35	72	31	29	7,584
1996	2,613	1,285	2,279	1,412	670	172	84	23	54	8	8,600
1997	2,959	2,126	1,050	1,854	1,082	497	127	65	13	15	9,788
1998	16,014	2,422	1,741	857	1,431	775	354	91	49	49	23,783
1999	3,073	12,919	1,959	1,389	679	1,053	460	242	60	53	21,887
2000	1,009	2,466	10,198	1,573	1,087	496	775	314	167	82	18,167
2001	2,065	822	1,995	8,143	1,196	788	346	508	202	128	16,193
2002	569	1,684	664	1,560	6,374	851	563	209	347	374	13,195
2003	5,175	466	1,375	541	1,255	5,009	598	363	141	463	15,386
2004	523	4,237	382	1,122	440	993	3,710	410	241	361	12,419
2005	1,843	428	3,458	312	909	328	740	2,538	272	376	11,204
2006	2,140	1,509	350	2,811	251	698	189	471	1,560	275	10,254
2007	1,491	1,749	1,229	285	2,249	202	532	91	316	1,133	9,277

Table R26. Gulf of Maine haddock spawning stock biomass (mt) at age estimated from the VPA, 1977 to 2006.

<b>Year</b>	<b>Age 0</b>	<b>Age 1</b>	<b>Age 2</b>	<b>Age 3</b>	<b>Age 4</b>	<b>Age 5</b>	<b>Age 6</b>	<b>Age 7</b>	<b>Age 8</b>	<b>Age 9<sup>+</sup></b>	<b>Total (mt)</b>
1977	0	13	1,817	1,306	3,587	1,229	1,168	4	23	96	9,243
1978	0	3	366	6,576	1,921	2,892	618	841	0	68	13,285
1979	0	14	110	2,423	7,954	1,908	2,090	242	588	0	15,329
1980	0	10	535	880	3,088	6,775	1,652	1,711	153	436	15,240
1981	0	5	394	3,001	1,177	2,473	4,972	1,333	1,378	179	14,912
1982	0	2	193	1,778	4,090	985	1,794	3,523	953	641	13,959
1983	0	3	44	1,289	1,559	3,169	754	1,052	1,874	745	10,489
1984	0	2	84	204	1,446	1,029	1,953	493	549	1,193	6,953
1985	0	1	73	544	321	990	693	1,250	322	365	4,559
1986	0	1	22	377	463	239	490	392	613	101	2,698
1987	0	0	31	108	365	238	102	250	196	135	1,425
1988	0	1	9	142	114	275	138	35	127	35	876
1989	0	1	36	97	145	109	143	50	14	7	602
1990	0	1	41	353	159	93	80	56	14	0	797
1991	0	1	37	243	308	148	40	7	7	5	796
1992	0	1	34	202	310	227	79	7	0	19	879
1993	0	3	52	198	132	277	164	63	2	5	896
1994	0	3	111	366	241	96	242	136	41	28	1,264
1995	0	4	99	775	455	254	100	242	123	147	2,199
1996	0	2	118	1,075	960	338	224	60	154	23	2,954
1997	0	6	131	1,673	1,486	964	311	196	37	54	4,858
1998	0	8	147	835	2,520	1,406	861	269	144	132	6,322
1999	0	23	156	1,060	953	1,719	874	577	183	166	5,711
2000	0	7	729	756	1,308	796	1,311	615	376	250	6,148
2001	0	2	168	4,749	1,158	1,182	611	991	438	296	9,595
2002	0	3	43	955	7,137	1,205	1,000	459	731	925	12,458
2003	0	1	99	244	1,299	6,641	953	720	333	1,078	11,368
2004	0	11	25	550	456	1,248	5,455	727	476	735	9,683
2005	0	1	236	171	801	412	968	3,930	496	794	7,809
2006	0	4	22	1,381	187	835	257	668	2,474	517	6,345

Table R27. Gulf of Maine haddock January 1 biomass (mt) at age estimated from the VPA, 1977 to 2007.

<b>Year</b>	<b>Age 0</b>	<b>Age 1</b>	<b>Age 2</b>	<b>Age 3</b>	<b>Age 4</b>	<b>Age 5</b>	<b>Age 6</b>	<b>Age 7</b>	<b>Age 8</b>	<b>Age 9<sup>+</sup></b>	<b>Total (mt)</b>
1977	25	456	7,945	1,730	4,047	1,468	1,364	25	26	112	17,198
1978	61	100	1,581	9,204	2,136	3,257	810	918	0	80	18,147
1979	45	503	472	3,353	9,142	2,126	2,273	285	644	0	18,843
1980	38	345	2,353	1,187	3,679	7,950	1,875	1,918	172	492	20,009
1981	8	188	1,806	4,148	1,397	2,846	5,664	1,475	1,562	203	19,297
1982	45	65	848	2,684	4,665	1,090	2,088	4,155	1,118	752	17,510
1983	13	109	189	1,863	2,012	3,775	892	1,318	2,285	908	13,364
1984	4	74	360	276	1,754	1,194	2,275	566	638	1,386	8,527
1985	7	24	309	787	374	1,237	816	1,514	385	436	5,889
1986	12	39	91	549	644	300	599	488	755	124	3,601
1987	11	12	131	148	441	282	141	320	256	177	1,919
1988	4	28	36	191	126	331	181	48	168	47	1,160
1989	4	37	154	129	179	126	169	73	17	9	897
1990	4	28	171	525	171	114	101	103	20	0	1,237
1991	3	27	161	335	369	173	67	45	13	9	1,202
1992	26	34	143	313	351	257	86	10	0	21	1,241
1993	52	110	221	270	159	303	178	73	2	6	1,374
1994	82	94	468	494	264	103	260	147	44	30	1,986
1995	6	134	420	1,040	529	274	110	260	133	159	3,065
1996	126	77	495	1,436	1,056	364	239	69	167	25	4,054
1997	114	216	553	2,231	1,649	1,049	338	210	40	58	6,458
1998	136	298	623	1,107	2,776	1,602	947	300	158	146	8,093
1999	72	804	658	1,409	1,052	1,856	962	633	201	182	7,829
2000	17	233	3,083	1,012	1,446	871	1,457	687	419	278	9,503
2001	14	72	716	6,311	1,286	1,285	693	1,090	487	329	12,283
2002	32	101	181	1,261	7,735	1,316	1,116	506	813	1,029	14,090
2003	139	46	417	322	1,406	7,158	1,048	797	367	1,188	12,888
2004	5	380	105	724	501	1,343	5,998	805	524	809	11,194
2005	196	26	992	225	872	473	1,083	4,439	559	895	9,760
2006	28	139	92	1,826	201	894	308	738	2,791	583	7,600
2007	64	141	339	192	2,173	275	836	160	634	2,549	7,363

Table R28. Gulf of Maine haddock mean biomass (mt) at age estimated from the VPA, 1977 to 2006.

<b>Year</b>	<b>Age 0</b>	<b>Age 1</b>	<b>Age 2</b>	<b>Age 3</b>	<b>Age 4</b>	<b>Age 5</b>	<b>Age 6</b>	<b>Age 7</b>	<b>Age 8</b>	<b>Age 9<sup>+</sup></b>	<b>Total (mt)</b>
1977	50	853	8,597	1,927	3,655	1,114	1,137	3	22	83	17,441
1978	175	202	2,962	9,522	2,255	2,844	524	866	0	58	19,408
1979	125	1,434	1,070	3,664	8,832	1,940	1,975	205	482	0	19,727
1980	85	958	3,605	1,303	3,398	6,771	1,779	1,777	162	391	20,229
1981	22	412	2,940	4,787	1,315	2,525	5,172	1,310	1,368	160	20,011
1982	70	179	1,653	2,282	4,516	1,022	1,737	3,207	870	556	16,092
1983	31	176	210	1,936	1,719	2,858	699	906	1,593	627	10,755
1984	10	176	731	352	1,556	1,038	1,962	503	548	1,042	7,918
1985	16	59	536	745	363	938	643	1,125	281	311	5,017
1986	12	90	142	476	432	215	423	349	517	84	2,740
1987	17	12	198	142	410	264	84	236	183	108	1,654
1988	13	44	113	179	115	269	109	32	122	28	1,024
1989	10	108	539	143	145	125	115	45	13	6	1,249
1990	10	77	273	416	208	93	71	49	11	0	1,208
1991	10	72	324	378	349	120	32	6	5	3	1,299
1992	54	115	279	237	327	210	74	5	0	18	1,319
1993	70	225	424	251	123	292	167	63	2	5	1,622
1994	105	127	970	560	289	108	240	130	36	26	2,591
1995	21	172	1,382	1,079	456	258	106	285	138	136	4,033
1996	165	276	1,431	1,465	1,033	329	230	42	98	21	5,090
1997	185	285	1,110	3,402	1,807	1,055	345	191	44	50	8,474
1998	331	478	1,349	1,091	2,228	1,313	842	251	126	121	8,130
1999	130	1,933	906	1,463	981	1,558	769	484	168	152	8,544
2000	36	422	4,968	1,105	1,385	762	1,301	604	356	226	11,165
2001	37	147	1,199	7,974	1,460	1,195	596	945	403	268	14,224
2002	38	271	225	1,352	7,556	1,191	1,003	462	693	838	13,629
2003	230	55	642	461	1,456	6,625	921	653	295	984	12,322
2004	11	629	201	817	524	1,210	5,270	703	432	672	10,469
2005	165	60	1,568	251	912	382	907	3,601	436	711	8,993
2006	68	117	143	2,116	162	877	236	627	2,211	463	7,020

Table R29. Gulf of Maine haddock fishing mortality (F) at age estimated from the VPA, 1977 to 2006.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Avg. F <sub>4-8</sub>
1977	0.005	0.117	0.156	0.030	0.202	0.512	0.421	7.325	0.432	0.432	1.778
1978	0.002	0.003	0.113	0.252	0.143	0.275	0.884	0.154	0.481	0.481	0.387
1979	0.017	0.028	0.071	0.206	0.276	0.234	0.136	0.452	0.163	0.163	0.252
1980	0.018	0.020	0.183	0.106	0.420	0.440	0.308	0.256	0.282	0.282	0.341
1981	0.006	0.048	0.342	0.202	0.406	0.362	0.321	0.207	0.301	0.301	0.319
1982	0.112	0.143	0.178	0.556	0.245	0.204	0.407	0.461	0.440	0.440	0.351
1983	0.003	0.061	0.048	0.381	0.740	0.501	0.472	0.702	0.593	0.593	0.602
1984	0.000	0.016	0.091	0.119	0.490	0.394	0.412	0.348	0.401	0.401	0.409
1985	0.001	0.019	0.044	0.383	0.336	0.688	0.456	0.565	0.517	0.517	0.512
1986	0.064	0.090	0.000	0.413	1.043	0.712	0.607	0.671	0.632	0.632	0.733
1987	0.021	0.065	0.019	0.166	0.475	0.478	1.111	0.783	0.884	0.884	0.746
1988	0.000	0.033	0.000	0.090	0.132	0.548	0.875	1.103	0.910	0.910	0.714
1989	0.000	0.001	0.041	0.047	0.576	0.358	0.451	1.319	0.626	0.626	0.666
1990	0.008	0.010	0.006	0.498	0.029	0.624	0.752	2.205	1.220	1.220	0.966
1991	0.009	0.017	0.115	0.190	0.445	0.440	1.825	7.449	2.273	2.273	2.486
1992	0.002	0.024	0.060	0.664	0.214	0.299	0.096	1.431	0.175	0.175	0.443
1993	0.002	0.004	0.041	0.148	0.480	0.153	0.118	0.397	0.184	0.184	0.267
1994	0.005	0.011	0.010	0.106	0.080	0.056	0.095	0.137	0.108	0.108	0.095
1995	0.000	0.004	0.020	0.084	0.319	0.110	0.204	0.091	0.127	0.127	0.170
1996	0.006	0.003	0.006	0.066	0.100	0.101	0.061	0.365	0.119	0.119	0.149
1997	0.000	0.000	0.003	0.059	0.134	0.138	0.131	0.086	0.115	0.115	0.121
1998	0.015	0.012	0.026	0.033	0.106	0.322	0.179	0.229	0.189	0.189	0.205
1999	0.020	0.037	0.020	0.045	0.113	0.107	0.181	0.170	0.177	0.177	0.150
2000	0.006	0.012	0.025	0.074	0.122	0.162	0.223	0.244	0.229	0.229	0.196
2001	0.004	0.013	0.047	0.045	0.141	0.136	0.301	0.181	0.228	0.228	0.198
2002	0.000	0.003	0.004	0.017	0.041	0.153	0.238	0.192	0.225	0.225	0.170
2003	0.000	0.000	0.003	0.007	0.035	0.100	0.178	0.209	0.190	0.190	0.142
2004	0.001	0.003	0.002	0.011	0.093	0.094	0.180	0.208	0.183	0.183	0.152
2005	0.000	0.002	0.007	0.016	0.064	0.354	0.251	0.287	0.279	0.279	0.247
2006	0.002	0.005	0.004	0.023	0.016	0.072	0.528	0.198	0.282	0.282	0.219

Table R30. Input values for Gulf of Maine haddock biological reference point calculations based on 2002 to 2006 average values from the VPA base run.

<b>Age</b>	<b>Fishery selectivity</b>	<b>Natural mortality</b>	<b>Stock weights (kg)</b>	<b>Catch weights (kg)</b>	<b>Spawning stock weights (kg)</b>	<b>Proportion mature (%)</b>
1	0.011	0.2	0.080	0.142	0.080	0.000
2	0.016	0.2	0.280	0.486	0.280	0.030
3	0.062	0.2	0.682	0.890	0.682	0.250
4	0.208	0.2	1.033	1.174	1.033	0.800
5	0.647	0.2	1.402	1.510	1.402	1.000
6	1.000	0.2	1.670	1.808	1.670	1.000
7	1.000	0.2	1.943	2.070	1.943	1.000
8	1.000	0.2	2.159	2.186	2.159	1.000
9	1.000	0.2	2.385	2.413	2.385	1.000

Table R31. Yield and biomass per recruit of Gulf of Maine haddock.

```
## Yield per Recruit and Spawning Stock Biomass per Recruit
## YPR Version 2.7
## Date of Run: 16 Apr 2008 13:19
## Input Data File: C:\BASHO\K_DRIVE_LOCAL\HADDOCK_GOM\GARM_III\YPR\GOM_HADDOCK_VPA_RUN12_YPR1.DAT
```

Model Title: YPR GoM haddock

Start Age = 1

End Age = 9 - Includes Plus Group with Maximum Age = 20

Fishing Mortality Upper Bound = 2.0000

Fishing Mortality Calculation Increment = 0.0001

Fishing Mortality Printing Increment = 0.01

Natural Mortality = 0.2000

Proportion Fishing Mortality Before Spawning = 0.2500

Proportion Natural Mortality Before Spawning = 0.2500

Age	Selectivity F	Selectivity M	Stock Weight	Catch Weight	SSB Weight	Maturity
1	0.0110	1.0000	0.0800	0.1420	0.0800	0.0000
2	0.0160	1.0000	0.2800	0.4860	0.2800	0.0300
3	0.0620	1.0000	0.6820	0.8900	0.6820	0.2500
4	0.2080	1.0000	1.0330	1.1740	1.0330	0.8000
5	0.6470	1.0000	1.4020	1.5100	1.4020	1.0000
6	1.0000	1.0000	1.6700	1.8080	1.6700	1.0000
7	1.0000	1.0000	1.9430	2.0700	1.9430	1.0000
8	1.0000	1.0000	2.1590	2.1860	2.1590	1.0000
9	1.0000	1.0000	2.3850	2.4130	2.3850	1.0000

Reference Point	F	YPR	SSBR	TSBR	Mean Age	Mean GT	Exp Spawn
F Zero	0.00000	0.00000	5.09104	6.11068	5.14351	8.80390	1.79964
F-01	0.31850	0.49703	2.20053	3.20245	3.37596	6.16899	1.10311
F-Max	1.37330	0.58975	0.93245	1.88760	2.61084	4.69487	0.50676
F at 40 %MSP	0.36780	0.51621	2.03671	3.03539	3.27518	5.98042	1.03993

Table R32. Stock recruitment model diagnostics for Gulf of Maine haddock.

Beverton Holt Stock Recruitment Relationship  
 Multiplicative Uncorrelated Lognormal Errors  
 30 Number\_of\_data\_points 30  
 3 Number\_of\_parameters 3  
 49.1482 Fit\_negloglikelihood 49.1482  
 0 Penalty\_steepleness 0  
 0 Penalty\_slope 0  
 0 Penalty\_unfished\_R 0  
 49.1482 Negative\_loglikelihood 49.1482  
 105.22 Bias-corrected\_AIC 105.22  
 108.5 BIC 108.5

Parameter Point\_Estimate

Parameter	Point_Estimate
1.22363	MSY 1.22363
0.445	FMSY 0.445
4.16505	SMSY 4.16505
3.04671	alpha 3.04671
0 log(alpha)	0
1.41491	beta 1.41491
0.739829	steepness 0.739829
2.78409	R_at_input_SMAX 2.78409
15	Input SMAX 15
14.6789	unfished_S 14.6789
2.77885	unfished_R 2.77885
1.03137	sigma 1.03137
N/A	phi N/A
N/A	sigmaw N/A
N/A	last_residual_R N/A
N/A	last_logresidual_R N/A
1.7021	expected_lognormal_error_term 1.7021
N/A	prior_mean_steepleness N/A
N/A	prior_se_steepleness N/A
N/A	prior_mean_slope N/A
N/A	prior_se_slope N/A
N/A	prior_mean_unfished_R N/A
N/A	prior_se_unfished_R N/A

Table R33. Biological reference points for Gulf of Maine haddock from parametric stock-recruitment models and non-parametric empirical approaches.

<b>BRP approach</b>	Parametric (stock-recruit)			Non-parametric (yield per recruit)		
<b>F reference point</b>	$F_{MSY} = 0.445$			$F_{40\%} = 0.367$		
<b>Recruitment inputs</b>	Beverton-Holt (alpha = 3.04671, beta = 1.41491, steepness = 0.739829, sigma = 1.03137)			Empirical CDF of 1977 - 2006 age-1 recruitment time series		
	<b>SSB<sub>MSY</sub> (mt)</b>	<b>MSY (mt)</b>	<b>Age-1 recruitment (10<sup>6</sup>)</b>	<b>SSB<sub>MSY</sub> (mt)</b>	<b>MSY (mt)</b>	<b>Age-1 recruitment (10<sup>6</sup>)</b>
<b>10th percentile</b>	3,600	900	0.7	2,100	500	0.3
<b>25th percentile</b>	4,800	1,100	1.2	2,700	700	0.5
<b>50th percentile</b>	<b>6,700</b>	<b>1,400</b>	<b>2.5</b>	<b>3,700</b>	<b>900</b>	<b>1.4</b>
<b>75th percentile</b>	9,300	2,700	4.9	5,100	1,200	2.4
<b>90th percentile</b>	13,100	3,800	9.4	6,700	1,600	4.5

## 16.0 Figures

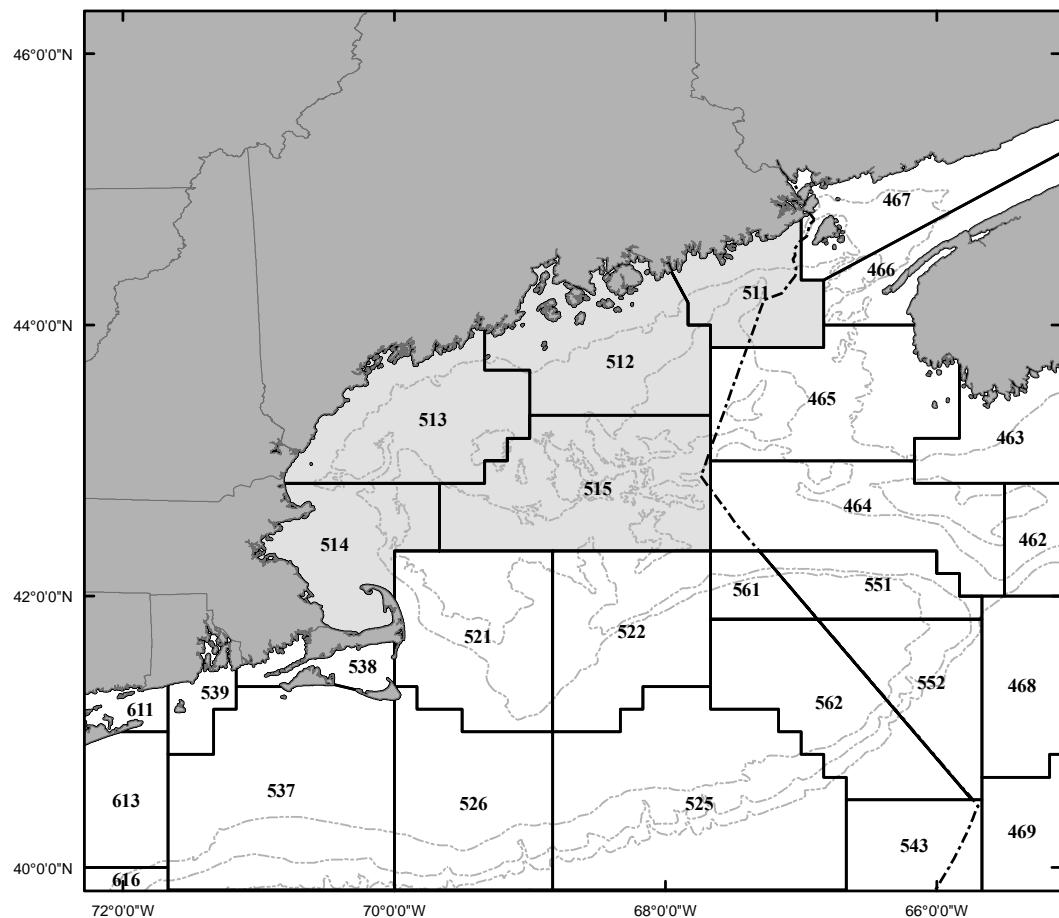


Figure R1. Statistical areas included in the Gulf of Maine haddock management unit (light grey). Northeast Atlantic Fisheries Organization (NAFO) division 5Y is comprised of United States statistical areas 511 – 515. Bathymetric contours corresponding to the 50, 100, and 500 fa contour lines are shown in light grey. Dashed line represents the United States Exclusive Economic Zone.

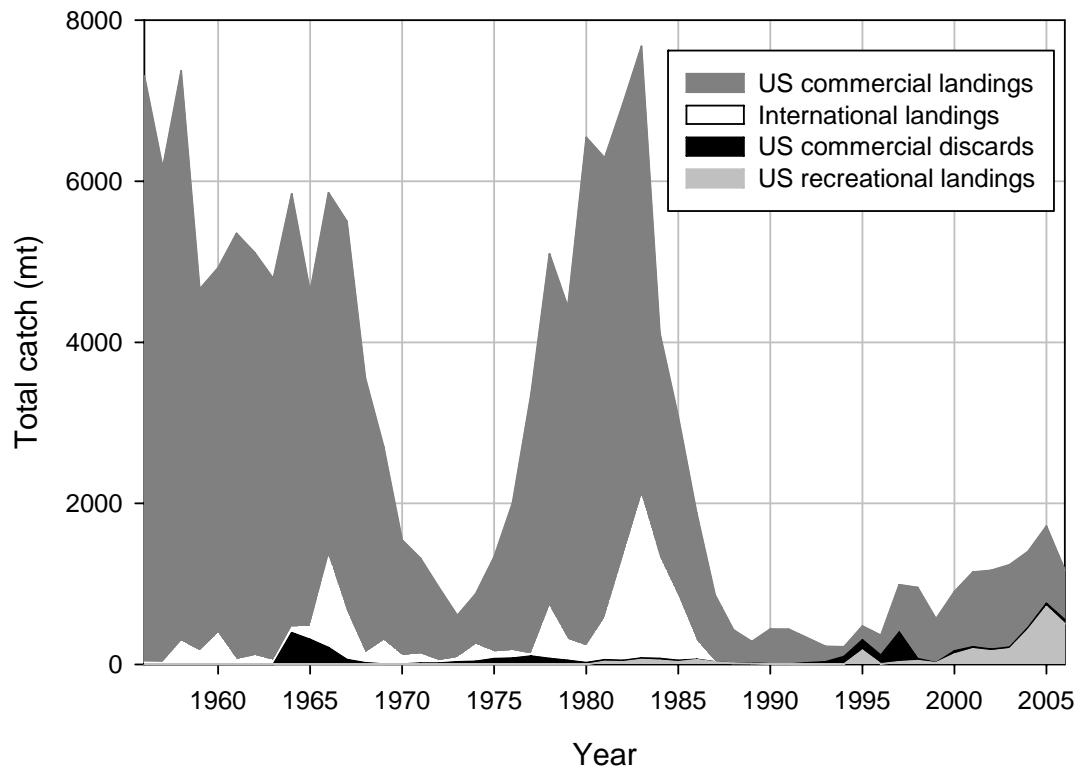


Figure R2. Total catch (mt) of Gulf of Maine haddock, 1956 – 2006.

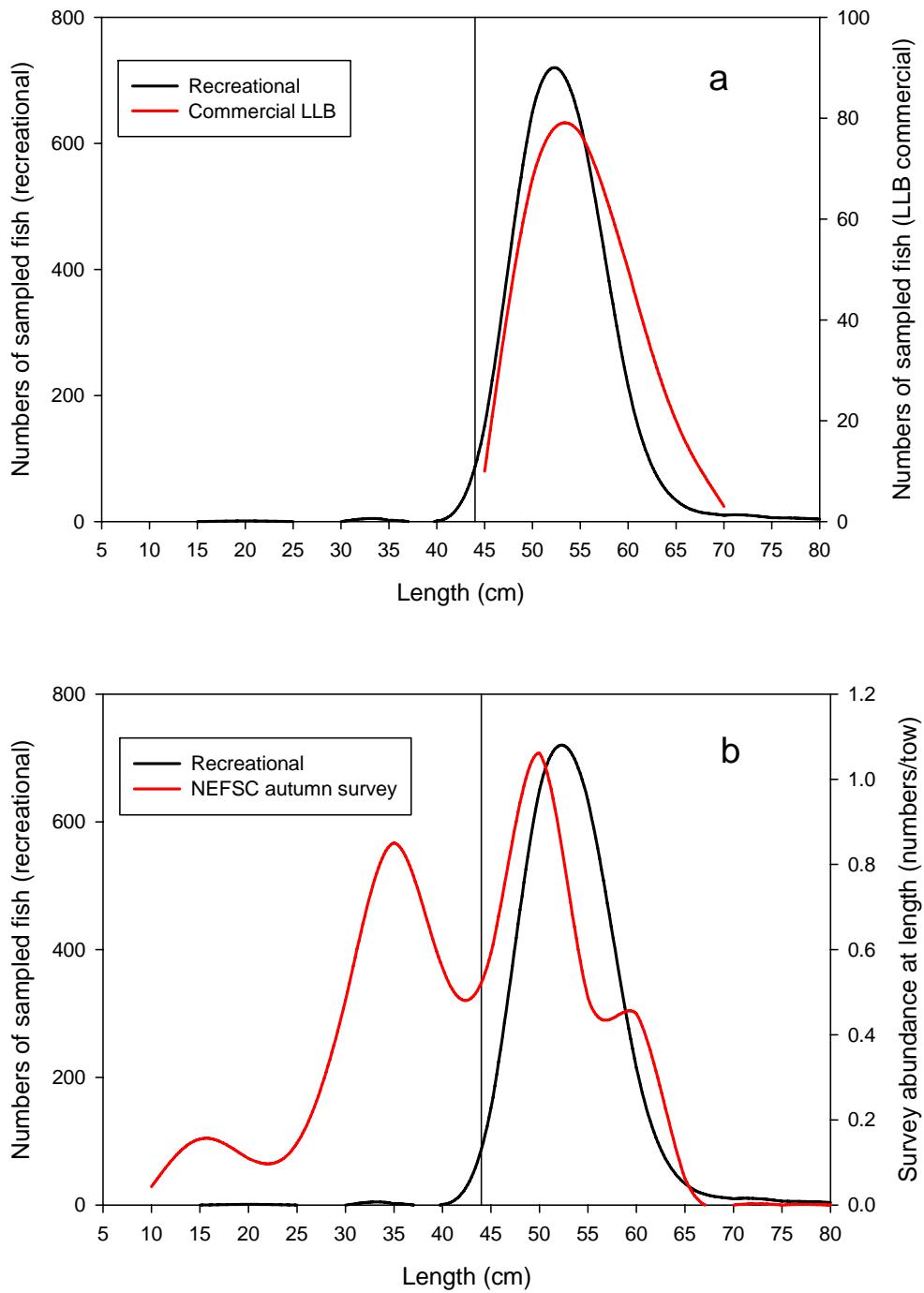


Figure R3. Selectivity of the recreational fishery relative to the commercial longline fishery (a) and Northeast Fisheries Science Center bottom trawl survey (b). Solid vertical lines indicate minimum legal size for recreational fishery. Data shown are from 2005.

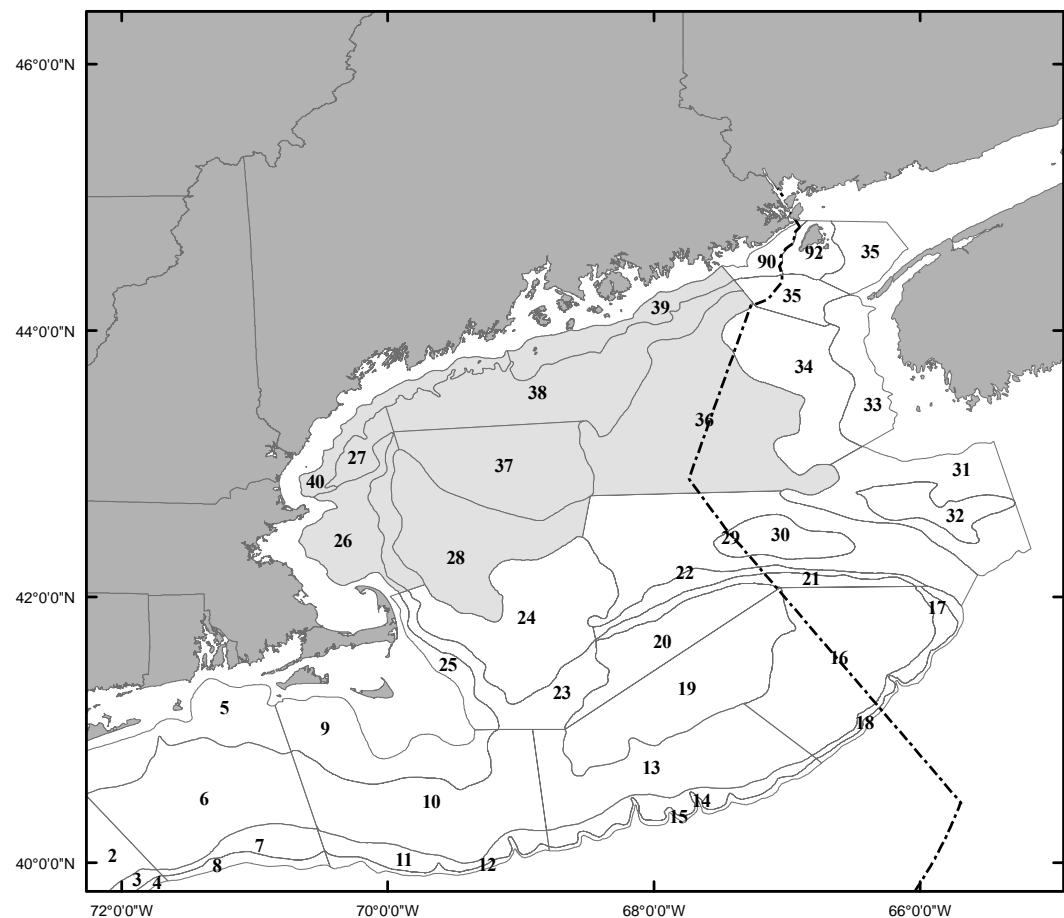


Figure R4. Northeast Fisheries Science Center (NEFSC) bottom trawl survey strata used to calculate the Gulf of Maine survey indices. Dashed line represents the United States Exclusive Economic Zone.

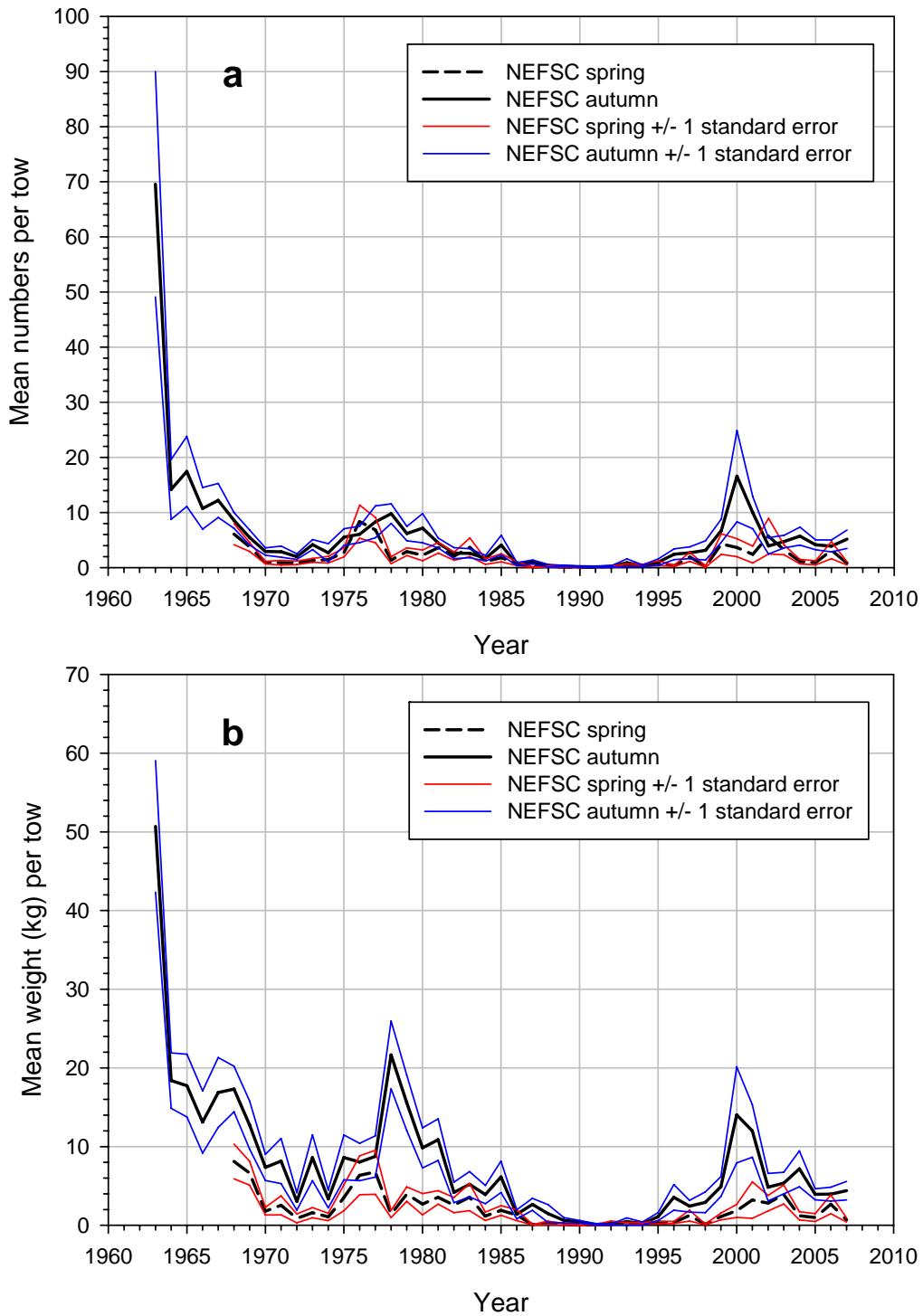


Figure R5. Northeast Fisheries Science Center (NEFSC) bottom trawl survey abundance (stratified mean numbers per tow) (a), and biomass (stratified mean weight (kg) per tow) (b) for Gulf of Maine haddock, 1963 – 2007. Indices have been corrected to account for changes in catchability due to changes in research vessels and doors.

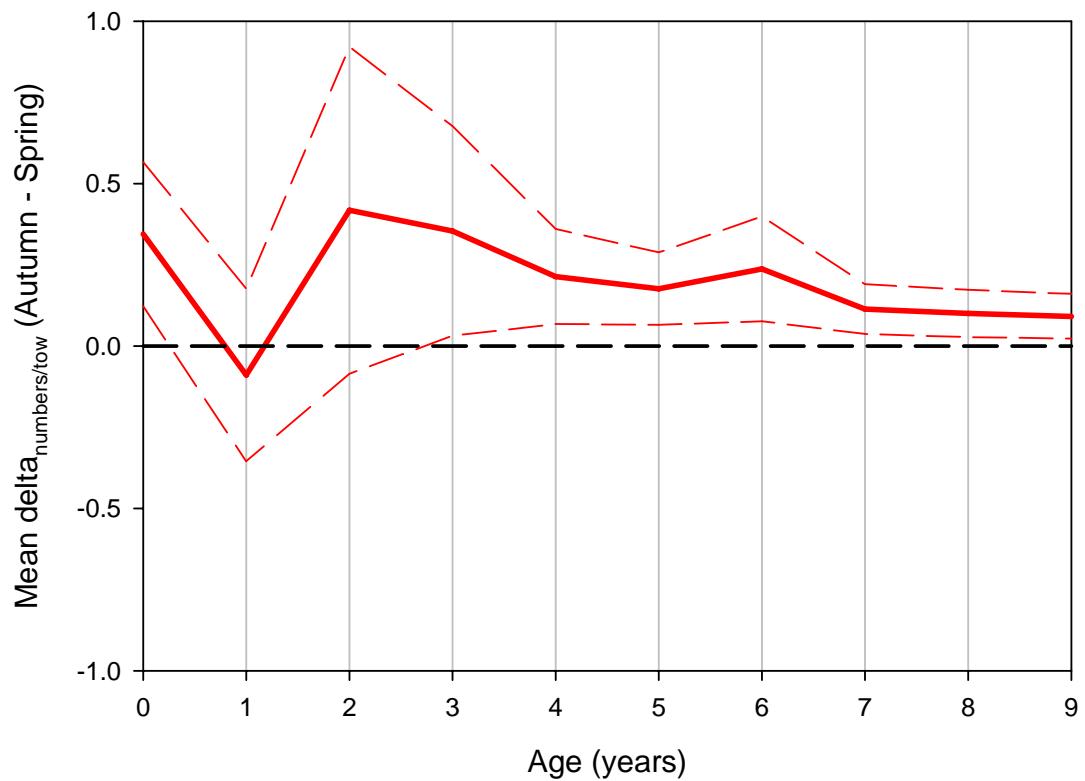


Figure R6. Mean differences in survey numbers/tow between the NEFSC autumn and spring bottom trawl surveys by age. Dashed red lines represent 95 % confidence intervals.

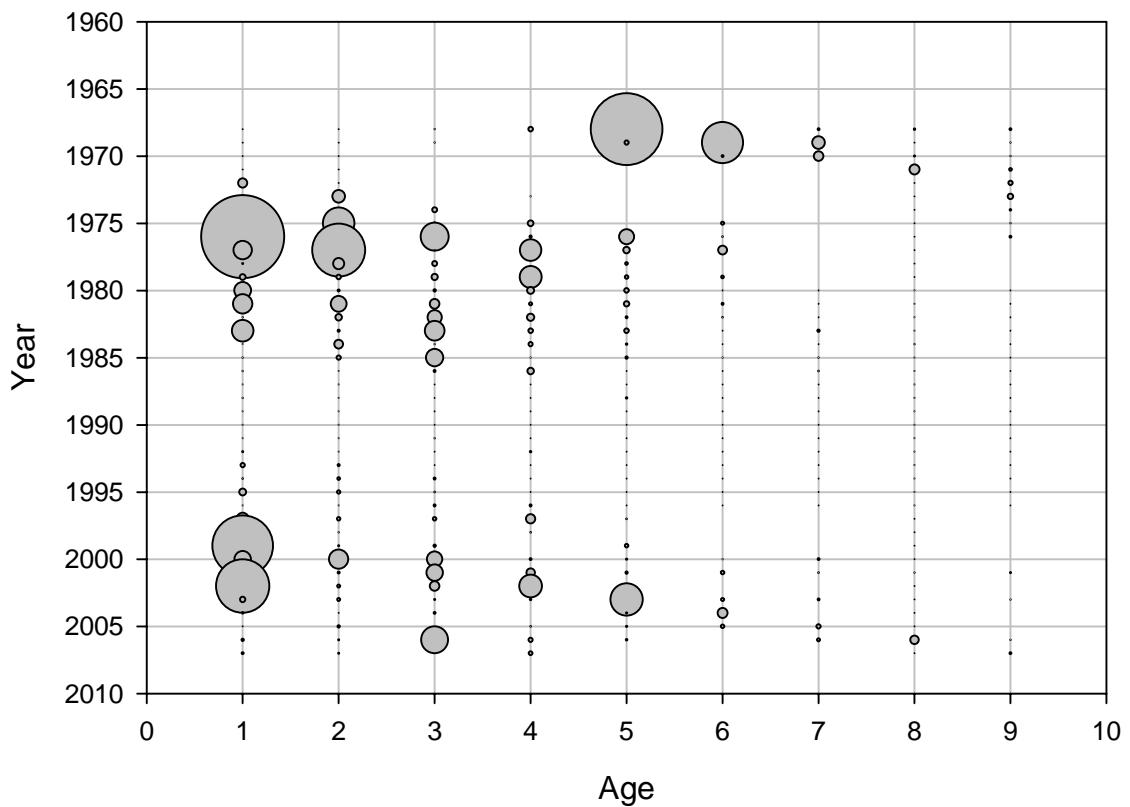


Figure R7. Age structure of the Gulf of Maine haddock population as indicated by the NEFSC spring bottom trawl survey indices of abundance, 1968 – 2007.

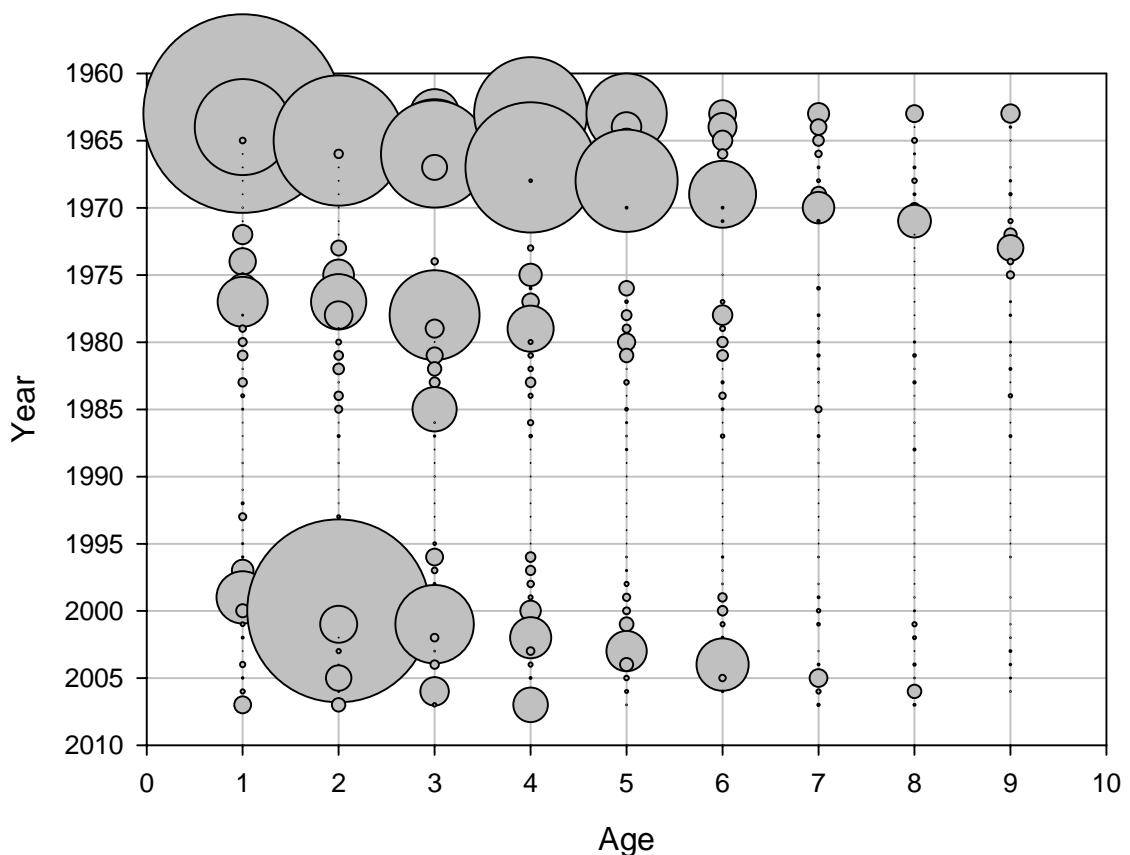


Figure R8. Age structure of the Gulf of Maine haddock population as indicated by the NEFSC autumn bottom trawl survey indices of abundance, 1963 – 2007.

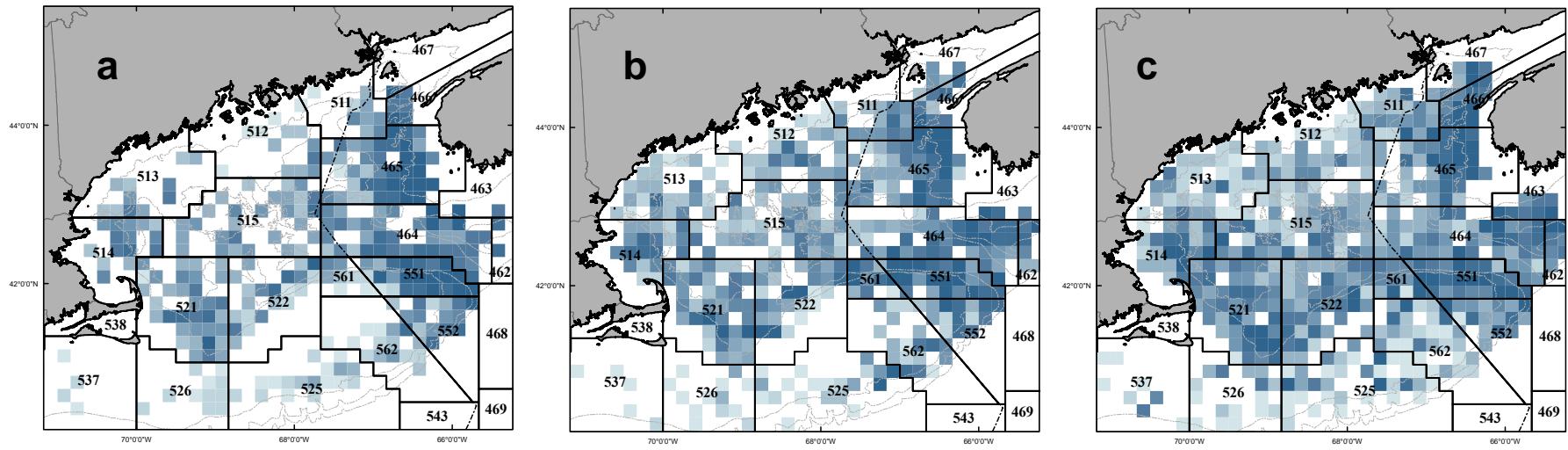


Figure R9. Distribution of haddock population in United States waters at low (< 4.0 kg/tow; a), medium (4.0 kt/tow – 8.0 kg/tow; b), and high (> 8.0 kg/tow; c) Gulf of Maine survey biomass levels as determined from Northeast Fisheries Science Center autumn bottom trawl survey. Shading represents decile distributions with darker colors indicating higher abundance.

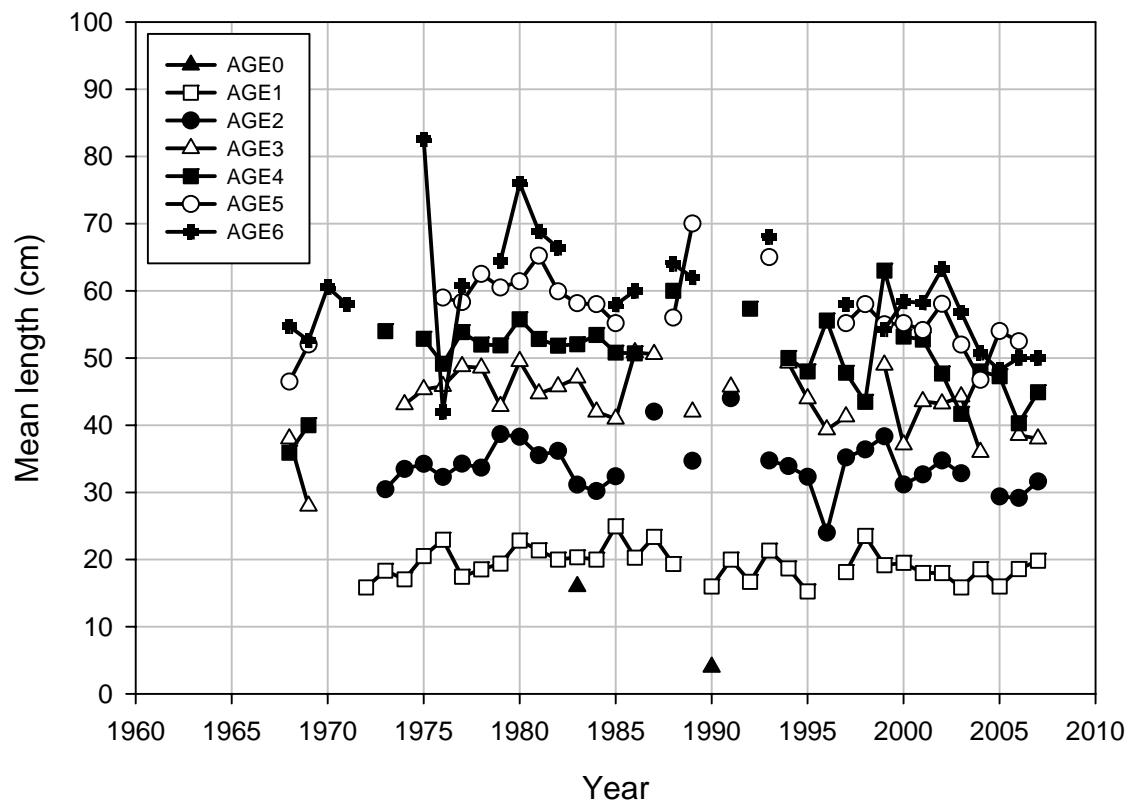


Figure R10. Mean length-at-age (cm) of age 0 to 6 Gulf of Maine haddock in the Northeast Fisheries Science Center's spring bottom trawl survey, 1968 – 2007.

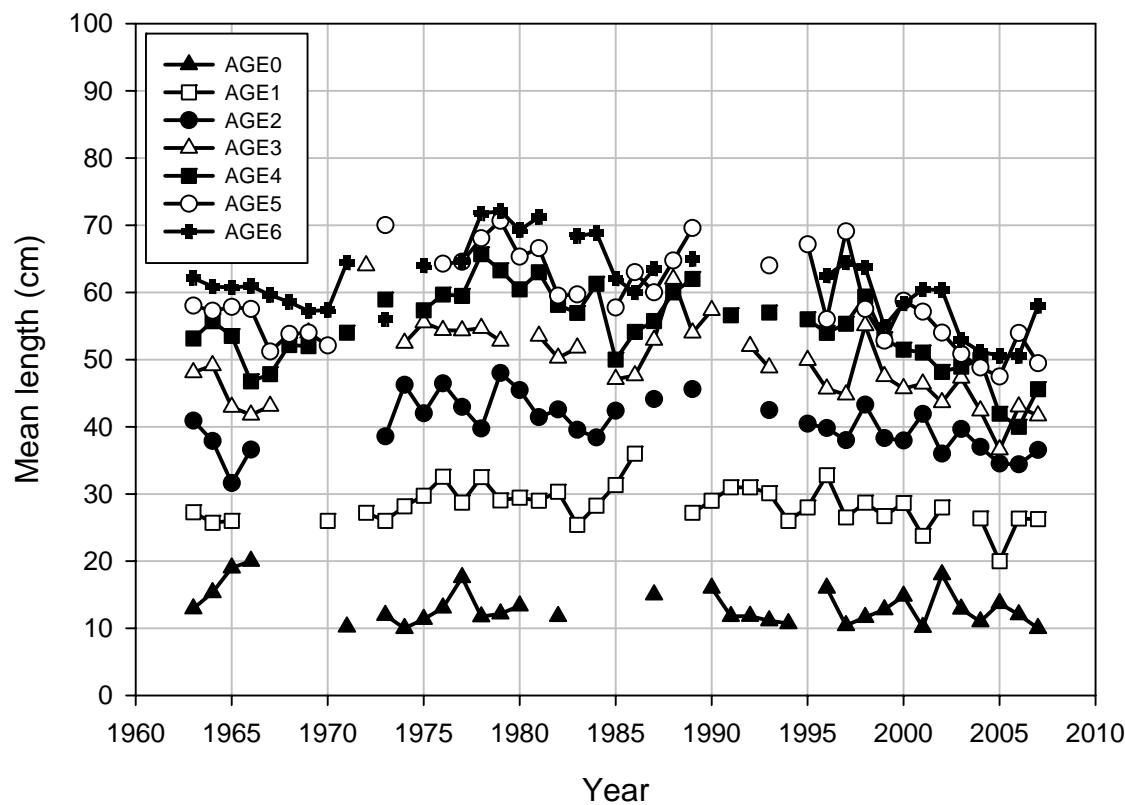


Figure R11. Mean length-at-age (cm) of age 0 to 6 Gulf of Maine haddock in the Northeast Fisheries Science Center's autumn bottom trawl survey, 1963 – 2007.

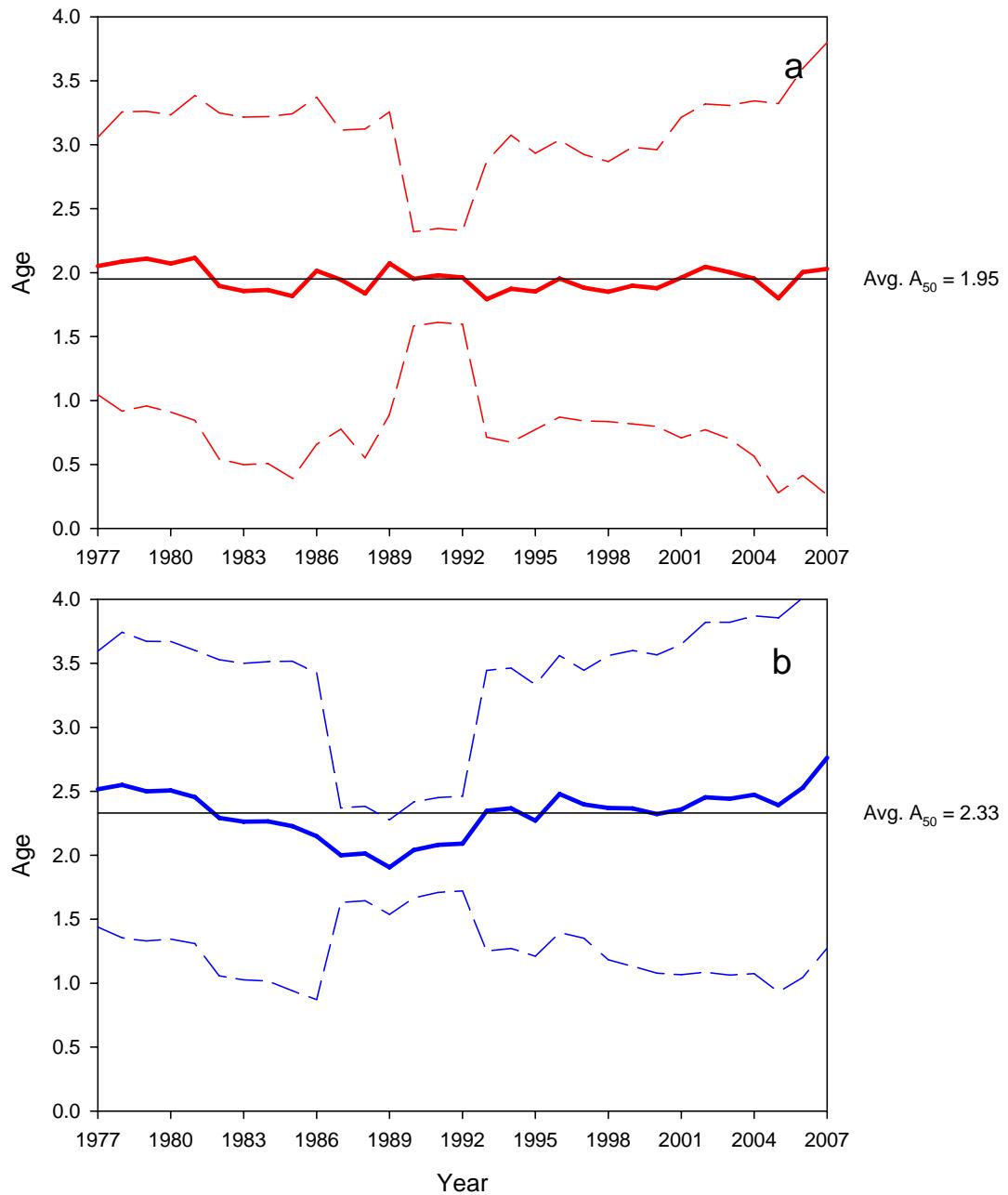


Figure R12. Age at 50 % maturity of both male (a) and female (b) haddock from the NEFSC spring bottom trawl survey, 1977 – 2007. Maturity at age was determined using 3-year centered moving average.

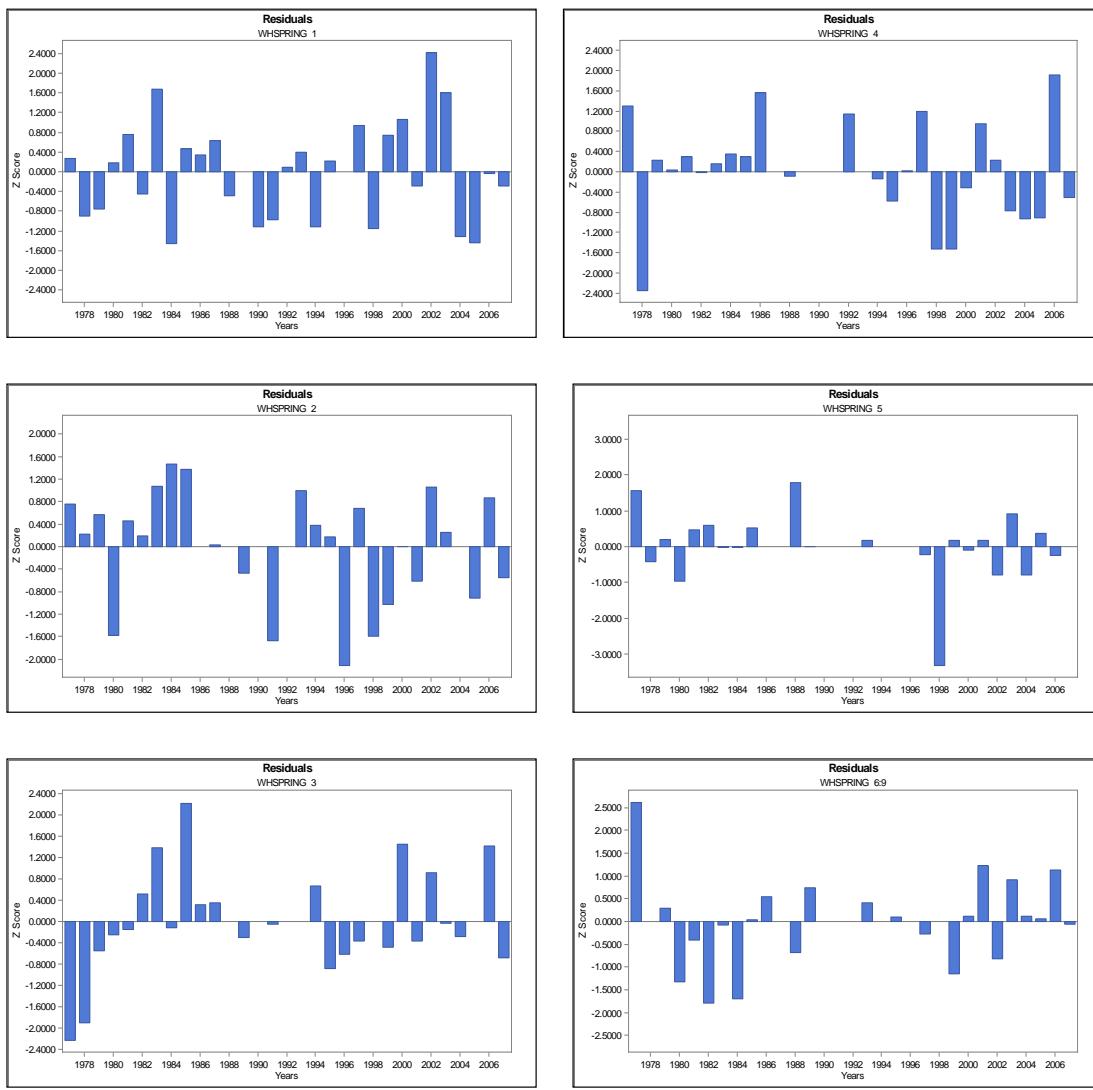


Figure R13. Standardized residuals for the age 1 through 6:9<sup>+</sup> spring survey indices used to tune the Virtual Population Analysis (VPA) for Gulf of Maine haddock.

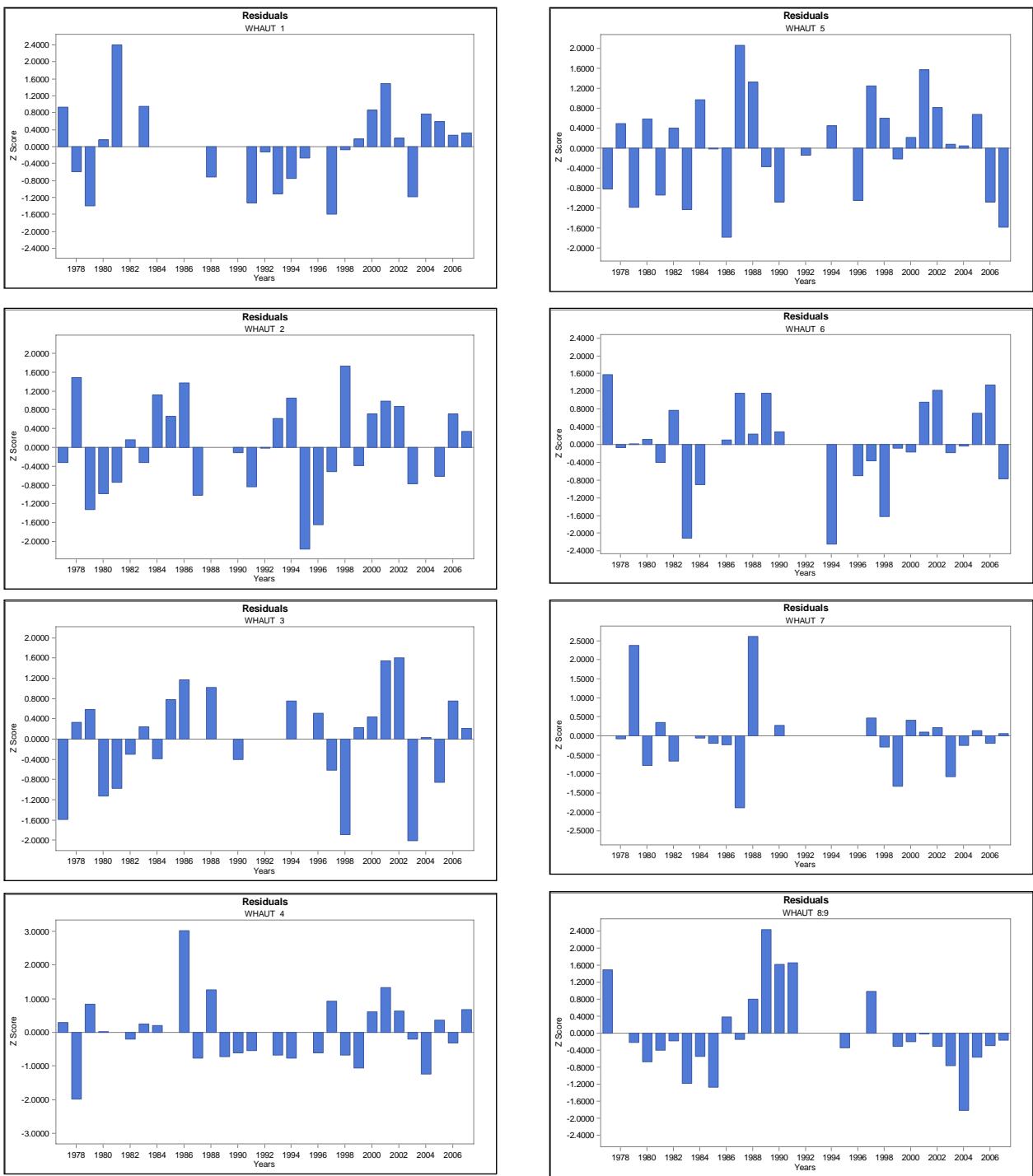


Figure R14. Standardized residuals for the age 1 through 8:9<sup>+</sup> autumn survey indices used to tune the Virtual Population Analysis (VPA) for Gulf of Maine haddock.

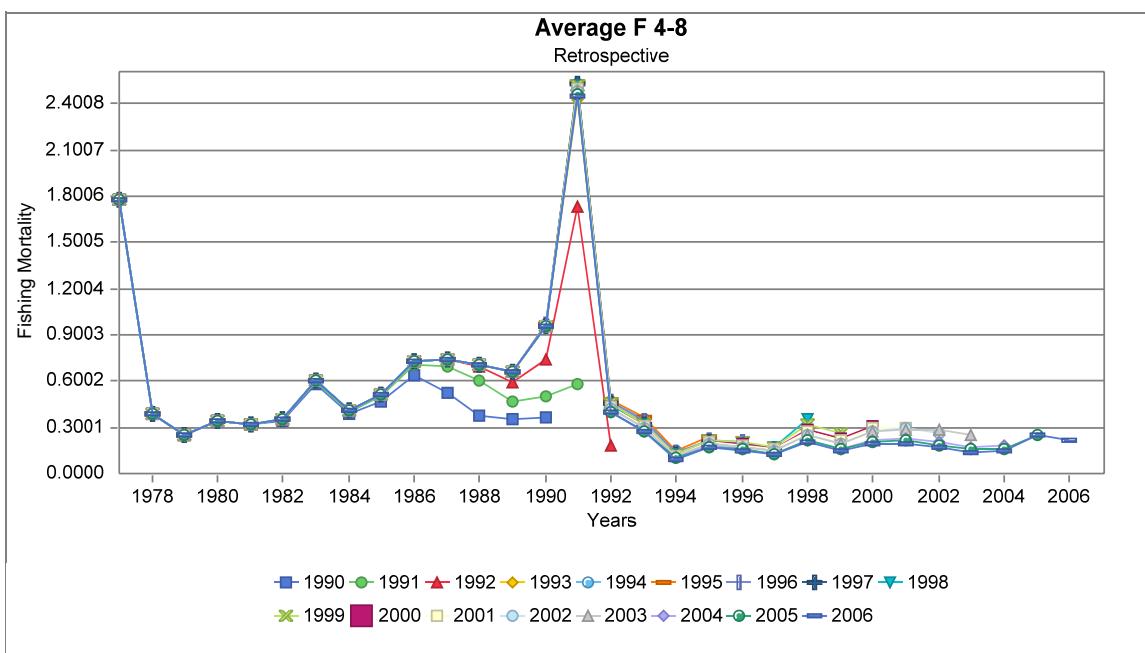


Figure R15. Retrospective plot of the Virtual Population Analysis (VPA) estimates of fully recruited F for Gulf of Maine haddock (F<sub>4-8</sub>).

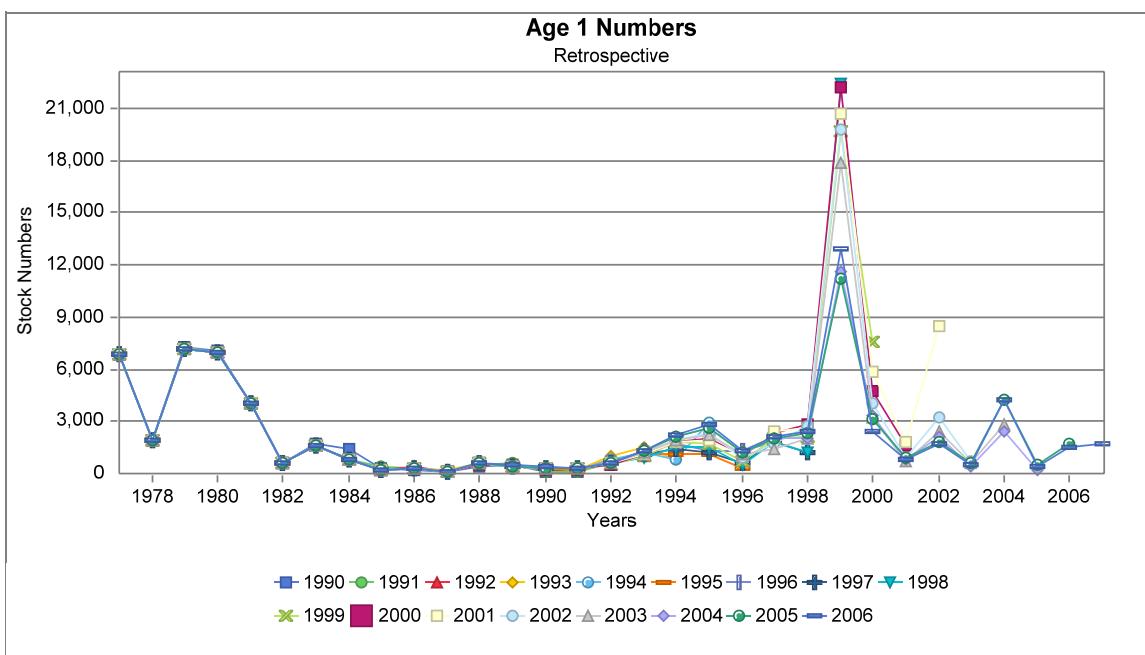


Figure R16. Retrospective plot of the Virtual Population Analysis (VPA) estimates of Gulf of Maine haddock age-1 recruitment (numbers).

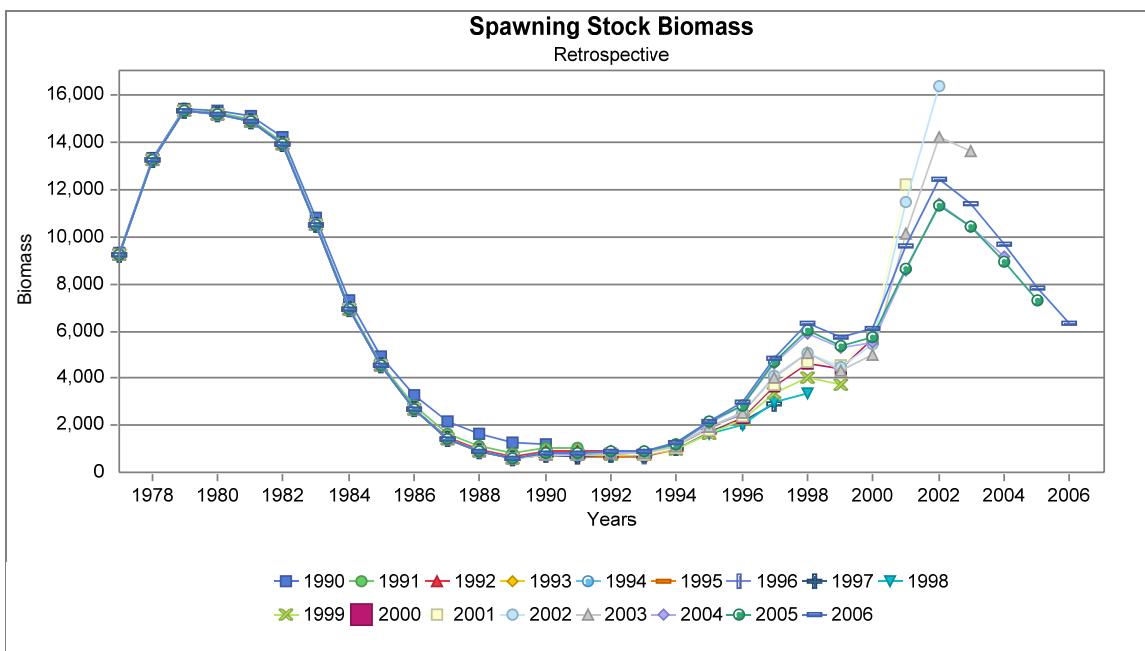


Figure R17. Retrospective plot of the Virtual Population Analysis (VPA) estimates of Gulf of Maine spawning stock biomass (mt).

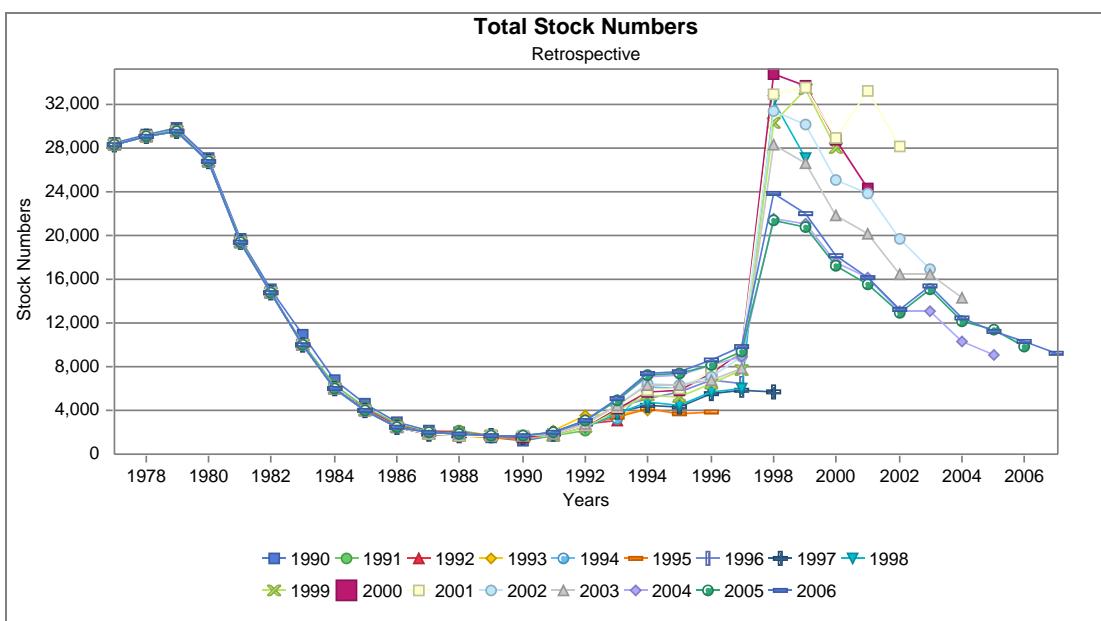


Figure R18. Retrospective plot for the Virtual Population Analysis (VPA) estimates of Gulf of Maine haddock January 1 population size (numbers).

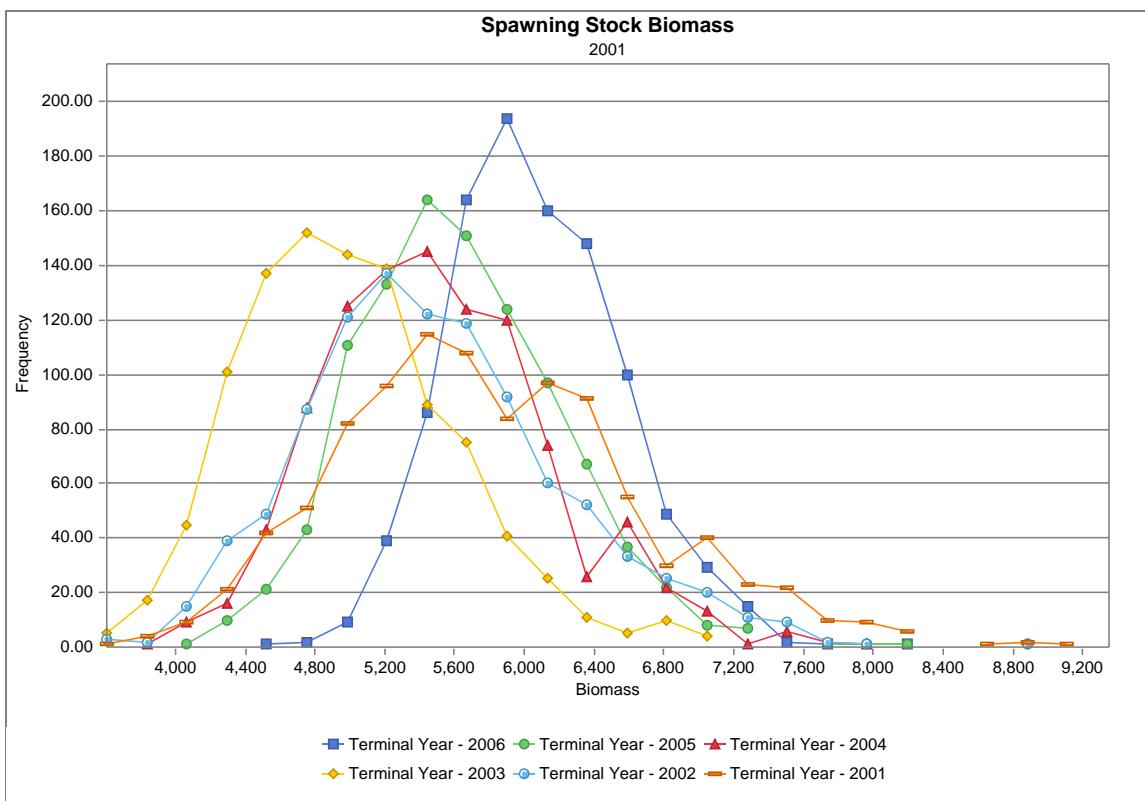


Figure R19. Bootstrap distributions of the Virtual Population Analysis (VPA) estimates of spawning stock biomass in 2001 from peeled assessments of Gulf of Maine haddock with different terminal years.

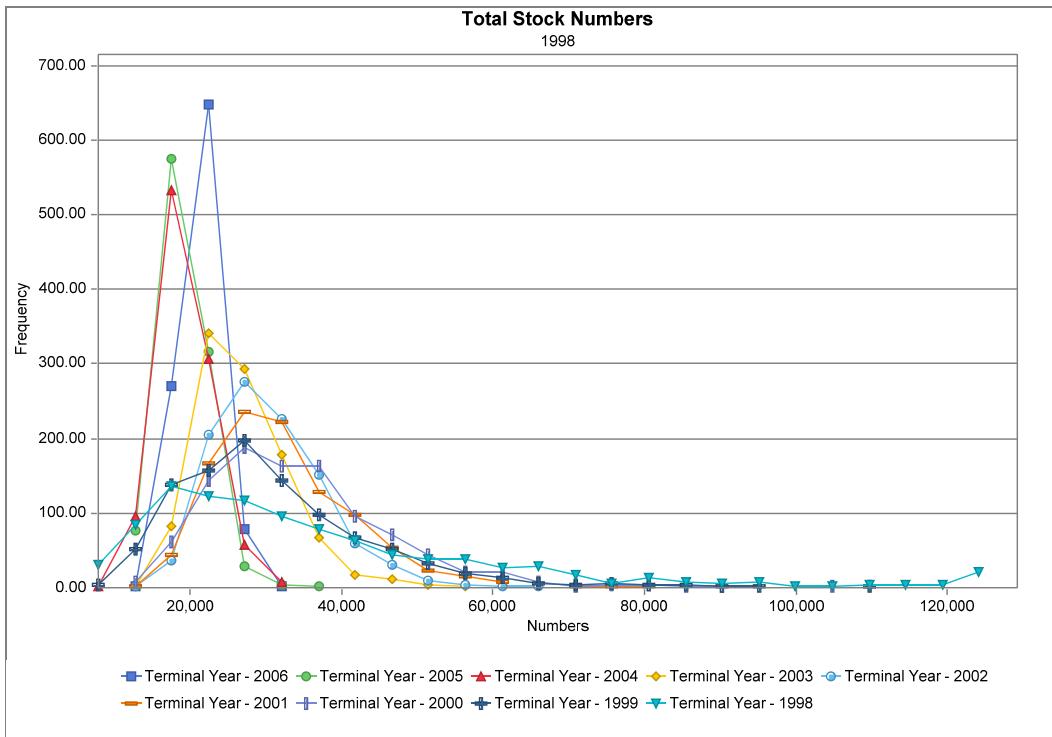


Figure R20. Bootstrap distributions of the Virtual Population Analysis (VPA) estimates of January 1 population size (numbers) in 1998 from peeled assessments of Gulf of Maine haddock with different terminal years.

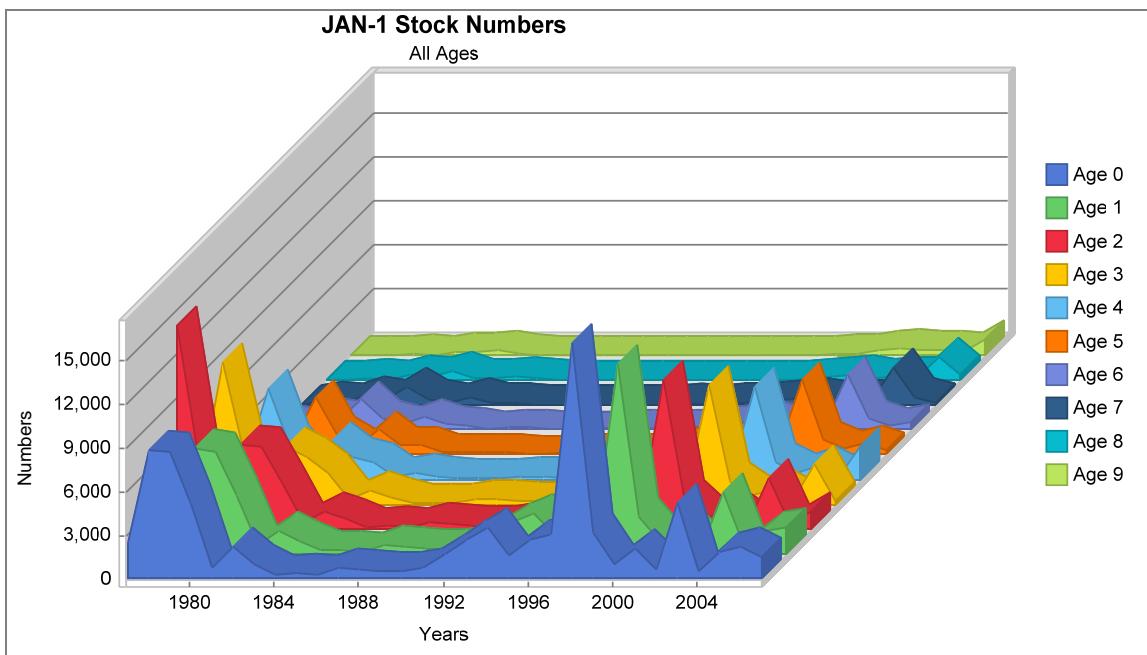


Figure R21. Virtual Population Analysis (VPA) of the Gulf of Maine haddock January 1 stock size at age.

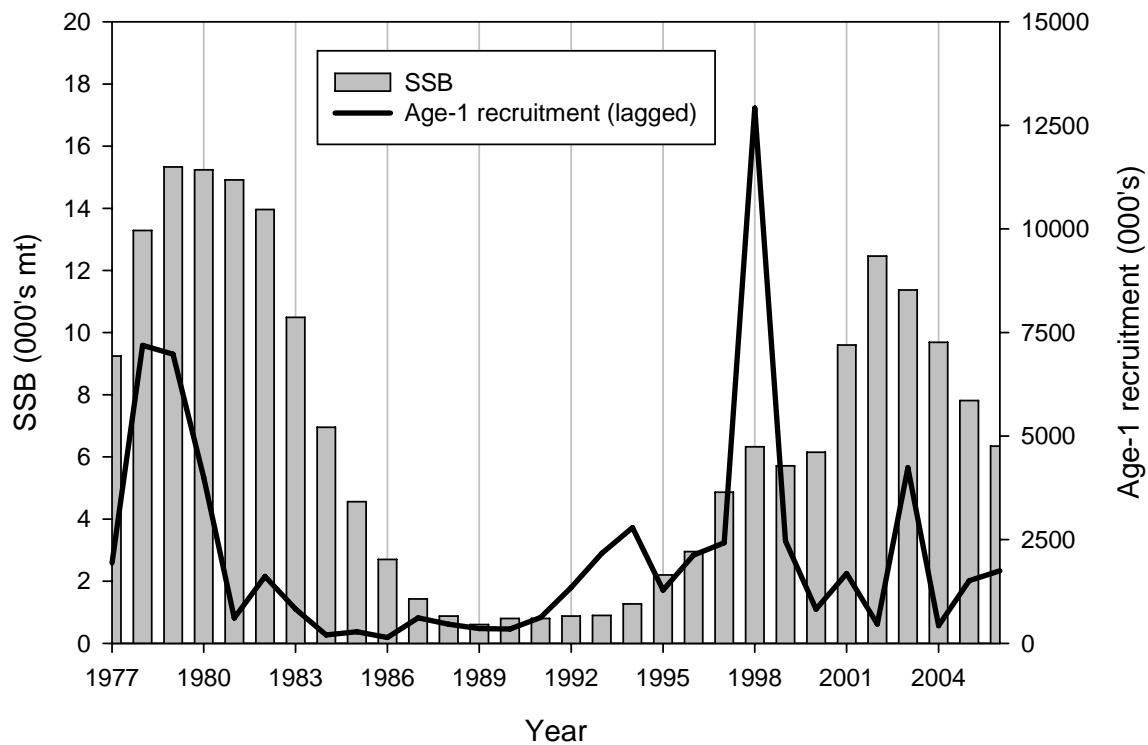


Figure R22. Trends in spawning stock biomass (000's mt) and age-1 recruitment (000's) for Gulf of Maine haddock, 1977 to 2006.

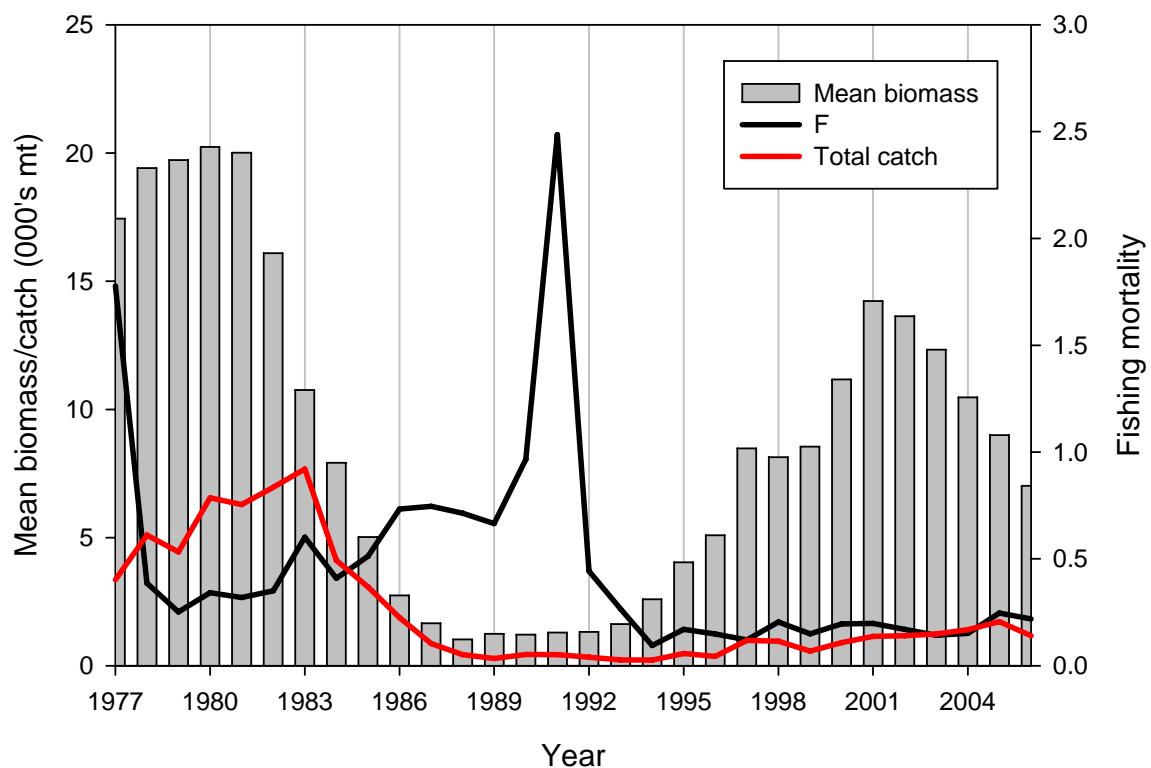


Figure R23. Trends in mean stock biomass (000's mt), total catch (commercial landings, discards and recreational landings, 000's mt) and fully recruited F ( $F_{4-8}$ ), 1977 to 2006.

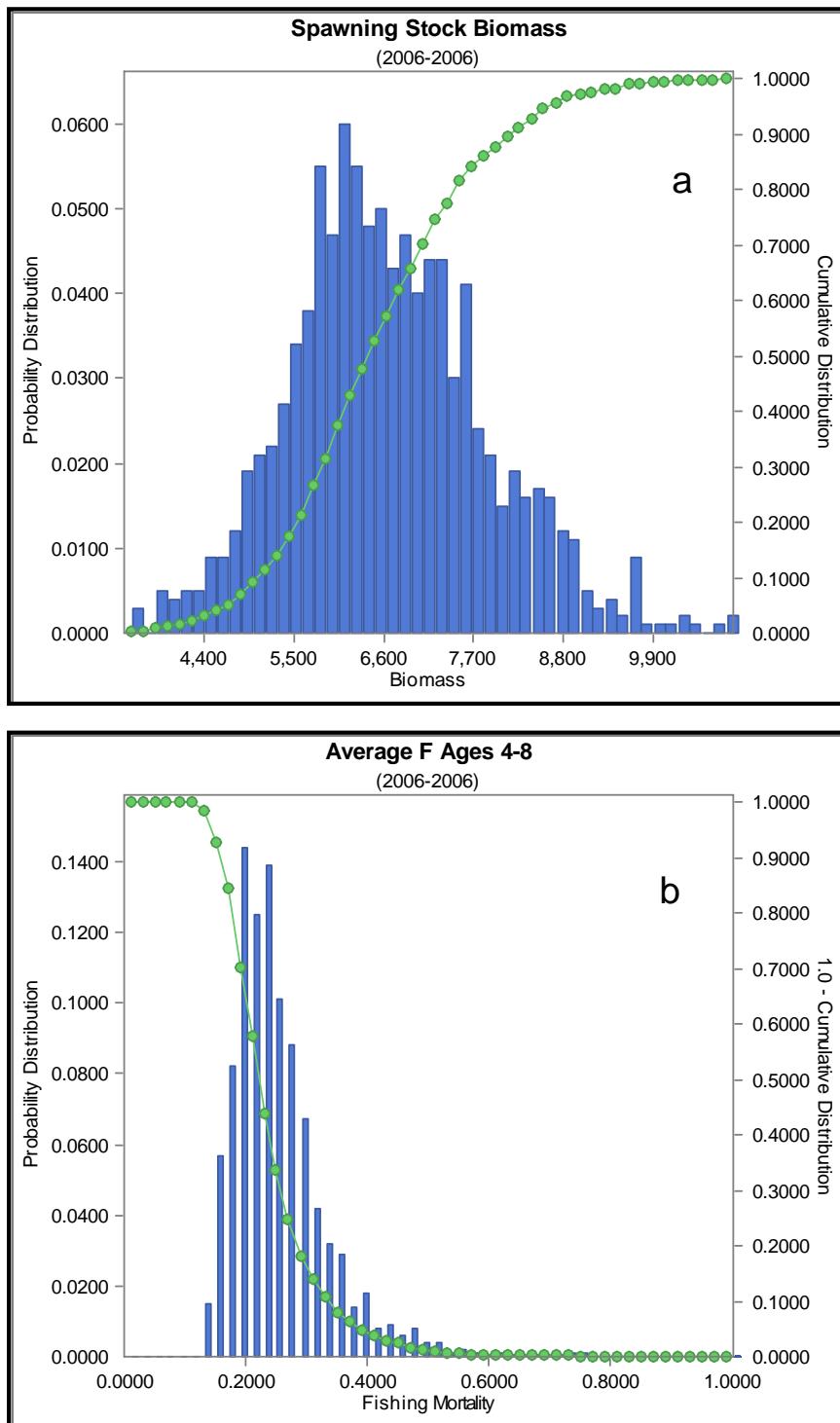


Figure R24. Precision of the estimates of Gulf of Maine haddock spawning stock biomass (a) and the instantaneous rate of fishing mortality (b) on fully recruited ages ( $F_{4-8}$ ) in 2006. The vertical bars provide the probability distribution of values of SSB and  $F_{4-8}$  from 1000 bootstrap realizations of the VPA. The solid line tracks the cumulative distribution.

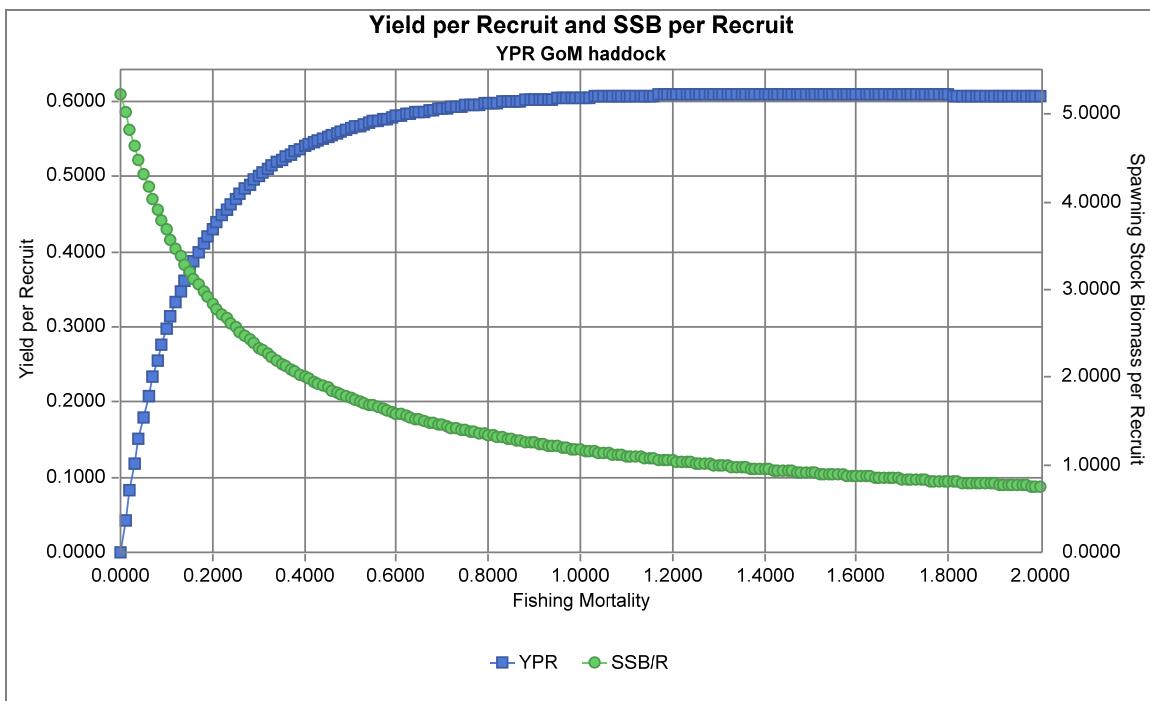


Figure R25. Yield (YPR) and spawning stock biomass (SSB/R) per recruit for Gulf of Maine haddock.

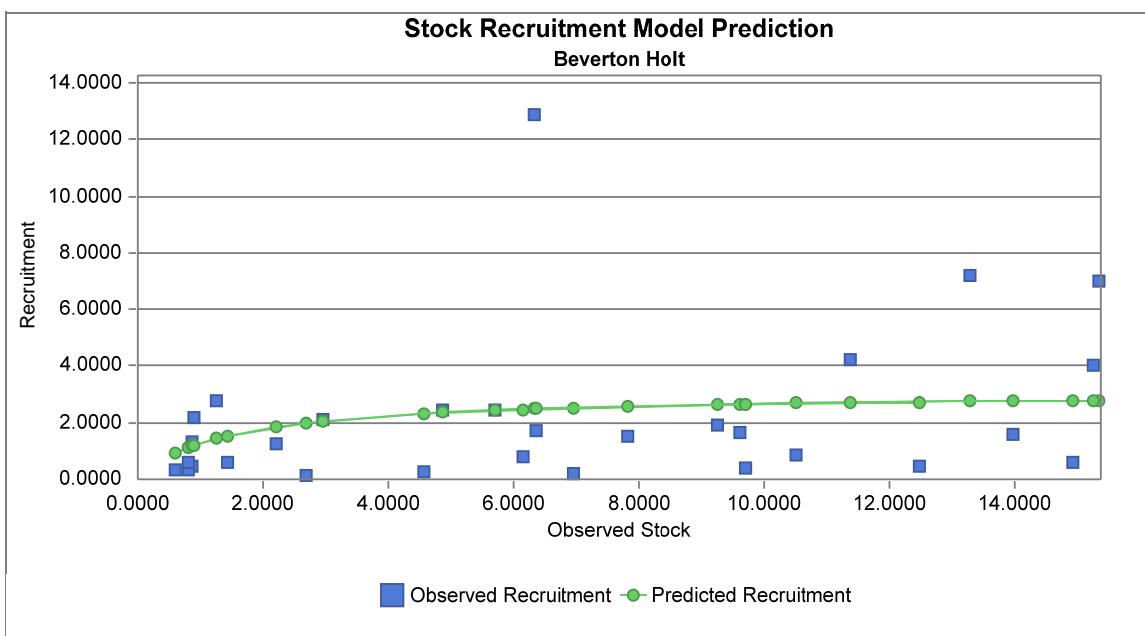


Figure R26. Beverton-Holt stock recruitment relationship for Gulf of Maine haddock  
(alpha = 3.04671, beta = 1.41491, steepness = 0.745074).

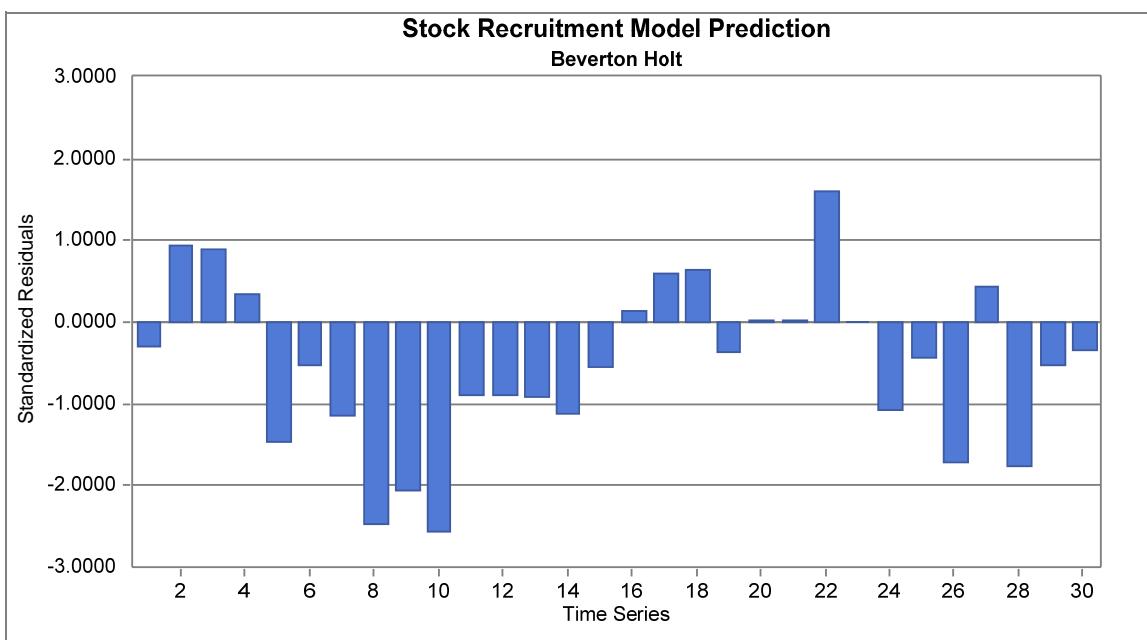


Figure R27. Standardized residuals from the Beverton-Holt stock recruitment fit for Gulf of Maine haddock.